

Health Technology Review

Drug-Checking Technologies to Detect Compositions of Unregulated Substance Samples

Key Messages

What Is the Issue?

- Drug toxicity and related death have been declared a public health emergency in Canada, driven largely by increasingly toxic unregulated fentanyl and opioid supplies contaminated with unexpected, high-potency opioids and other central nervous system and/or respiratory depressants (e.g., benzodiazepine, xylazine).
- Drug-checking technologies (DCTs) — referring here to the underlying analytical methods such as immunoassay or mass spectrometry — are used to determine the presence of specific substances or provide a comprehensive breakdown of the substance's composition. DCTs are used as part of drug-checking services to support safer use, increase awareness of substance compositions, connect people with health and social services, and inform public health responses to the toxic drug supply.
- There is a need to synthesize the available DCT evidence on accuracy, limit of detection, repeatability, reproducibility, cost-effectiveness, and costs for detecting compositions of unregulated substance samples.

What Did We Do?

- Based on the results of an initial scoping exercise and experts' feedback, we conducted a customized health technology review to inform decisions regarding the use of DCTs for detecting compositions of unregulated substance samples.
- We searched key resources, including journal citation databases, and conducted a focused internet search, with no publication date limits, for relevant evidence. We also sought costing information by contacting DCT manufacturers to obtain costing estimates in Canadian dollars.

What Did We Find?

- The body of evidence on the outcomes and capabilities of DCTs is small but growing.
- We found 18 test accuracy studies that evaluated the accuracy of any DCTs for detecting compositions of unregulated substance samples.
 - DCTs varied in accuracy outcomes depending on the substance and context. Immunoassay test strips (ITS) showed relatively high sensitivity and low to minimal false negative rates for target substances, whereas spectroscopic methods (e.g., Fourier transform infrared [FTIR] spectroscopy spectrometers) provided broader compositional information.

Key Messages

- Combining or advancing technologies improved performance. Pairing methods, such as FTIR with ITS, or using emerging DCTs, including portable gas chromatography–mass spectrometry and surface-enhanced Raman spectroscopy, enhanced sensitivity and reduced false negative rates.
- Colorimetric reagents and infrared spectroscopy were shown to have comparable high sensitivity against the confirmatory lab testing.
- We found 7 test accuracy studies that evaluated the limit of detection of any DCTs for detecting compositions of unregulated substance samples. Of these, 1 study also reported on the reproducibility of ITS. This review did not find any studies that reported results on the repeatability of DCTs that met our selection criteria for this review.
 - ITS (e.g., fentanyl test strips), FTIR, and hand-held Raman spectrometers were each able to detect the presence of target substances in samples, though their detection capabilities varied depending on the substance and concentration.
 - Xylazine test strips consistently detected xylazine in samples with low concentrations, across days.
- We did not find any studies on the relative cost-effectiveness of any DCTs for detecting compositions of unregulated substance samples that met our selection criteria for this review.
- We found 1 article that provided a cost description of a US pilot drug-checking service that employed an FTIR spectroscopy, fentanyl test strips, and confirmatory lab testing. The findings demonstrated the feasibility of drug checking in the evaluated context.
- Eleven manufacturers that we contacted provided cost information by completing surveys for 16 DCTs. Among the cost data received, 4 DCTs were technologies identified in the included test accuracy studies.
- Outcome measures and methods used for evaluation of DCTs were heterogeneous across the studies, and conclusions were often constrained by risks of bias and applicability. No studies were found that specifically address the performance of DCTs in distinct settings, such as rural or Indigenous communities. Well-designed, methodologically rigorous studies are needed to generate the evidence needed to confirm the accuracy and cost-effectiveness of DCTs.

Key Messages

What Does This Mean?

- This review includes several considerations for health care decision-makers, including those planning or implementing DCTs for use in clinical and community settings:
 - There is a trade-off between highly sensitive detection of a single substance (e.g., fentanyl) and broader screening capacity: ITS indicated high sensitivity and specificity in detecting target substances and may be used for early identification of toxic substances and their analogues; however, FTIR and Raman spectrometers offer the advantage of detecting multiple substances within a single sample.
 - A multitool approach may be preferable for drug checking and may better guide harm reduction messaging for people who use drugs: pairing point-of-care FTIR spectrometry and ITS combined with confirmatory lab testing can enhance sensitivity and reduce the false negative rate.
 - In the context of drug checking, certain test accuracy measures are more critical than others: studies most often reported on sensitivity, reflecting the importance of avoiding false negative results (i.e., failing to detect a harmful substance), and specificity, reflecting the problems with false positives, which can generate misinformation about the unregulated drug supply.
 - Innovations in emerging DCTs are specifically intended to balance trade-offs between sensitivity, specificity, cost, and ease of use. Most of these technologies are in the research, development, and evaluation stages, and some are in the field-testing stage.
 - Establishing national or regional guidelines for evaluation metrics, accuracy reporting, and service design specific for evaluation of DCTs may reduce variability in evidence.
 - Relevant costing estimates obtained from DCT manufacturers included in this report can be considered alongside operational and contextual factors (e.g., service delivery model, staff capacity, proximity to confirmatory testing facilities) when considering, planning, or implementing DCTs within their specific settings.
 - Along with the technical and cost considerations, ethics and equity considerations relevant to the context of DCTs, presented in this report, can be considered including those related to consent, access, legal requirements, and privacy.

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Abbreviations

BTS	benzodiazepine test strips
CCSA	Canadian Centre on Substance Use and Addiction
CDA-AMC	Canada's Drug Agency
DCS	drug-checking service
DCT	drug-checking technology
FN	false negative
FP	false positive
FTIR	Fourier transform infrared
FTS	fentanyl test strips
GC-MS	gas chromatography–mass spectrometry
IR	infrared spectroscopy
ITS	immunoassay test strips
LC-MS-MS	liquid chromatography–tandem mass spectrometry
LOD	limit of detection
MS	mass spectrometry
NDCWG	National Drug-Checking Working Group
NPV	negative predictive value
PPV	positive predictive value
PS-MS	paper spray–mass spectrometry
PWUD	people who use drugs
qNMR	quantitative nuclear magnetic resonance
SERS	surface-enhanced Raman spectroscopy
SUAP	Substance Use and Addictions Program
TN	true negative
TP	true positive
XTS	xylazine test strips

Key Terminology

Accuracy: Ability of the test to correctly classify substance samples and their compositions, and produce the same results as the validated technology to which it is being compared.¹ Accuracy of a test can be evaluated using the following outcomes: sensitivity, specificity, positive predictive value, negative predictive value, true positive, true negative, false positive, and false negative.

Confirmatory lab testing: Highly sensitive and specific drug-checking technologies used to validate the accuracy of the emerging and point-of-care drug-checking technologies.

Drug checking: A harm reduction intervention to analyze the content of substances that individuals intend to consume, rather than testing biological samples from individuals (e.g., drug testing in blood or urine).² Drug checking also supports timely monitoring of the unregulated drug supply to inform public health policies and harm reduction strategies on a broader scale.³

Drug toxicity: The harmful effects of a drug on the body. It occurs when a drug is taken in excessive amounts (also known as “drug overdose” and “drug poisoning”) or when the body cannot properly metabolize or eliminate the drug, leading to damage to organs, tissues, or physiological functions.^{4,5}

Drug toxicity crisis: A widespread public health emergency caused by high rates of drug toxicity and related deaths. A drug toxicity crisis is typically driven by the increased presence of highly potent and toxic substances, such as fentanyl in unknown amounts that is heavily contaminated with other unexpected substances.^{4,5}

Index test: The index test refers to the diagnostic or accuracy tests (i.e., what is called “drug-checking technologies” in this review) being assessed to determine how accurately they identify participants (i.e., substance samples in this review) who do or do not have the target condition (i.e., substance compositions in this review).

Limit of detection (LOD): The smallest amount or concentration of a substance or composition that the test can reliably detect. LOD defines the lowest detectable level at which the substance can be identified but not necessarily quantified.⁶ LOD can be evaluated by preparing reference standards with known concentrations of the target substances (e.g., xylazine) and analyzing multiple replicates at each concentration to determine the lowest concentration at which the composition is reliably detected in 95% of replicates (or based on a signal at least 3 times or 10 times the background noise).⁶

People who use drugs: Individuals who consume psychoactive substances, including prescription medications, alcohol, or illicit (nonpharmaceutical) drugs.⁷

Reference standard: The most accurate and reliable method available for determining whether the target condition (i.e., called “substance compositions” in this review) is present or absent. Reference standards are referred to as “confirmatory lab testing” in this review.

Repeatability or intraday (assay) precision: The consistency of the test when repeated under the same conditions (i.e., same sample, same instrument, same operator, short time frame). A precise test gives similar results each time it is used on the same sample.⁸

Reproducibility or interday (assay) precision: The consistency of the test when repeated in different conditions (i.e., different days, instruments, operators, or sites). Reproducibility captures how robust the method is in practice.⁸

Sensitivity: The ability of the test to correctly identify the presence of a substance when it is actually present. Sensitivity is sometimes referred to as the true positive fraction (called “true positive rate” in this review).¹ A highly sensitive test will detect even small amounts of the target substance.

Specificity: The ability of the test to correctly identify the absence of a substance when it is not present. Specificity is occasionally referred to as the true negative fraction (called “true negative rate” in this review).¹ A highly specific test will rarely give a false positive for a substance that is not actually in the sample.

Target substance(s): Specific drug(s) or chemical composition(s) that a technology or test is designed to detect and analyze in a sample.

Note. The language around substance use health has evolved significantly in recent years to reduce stigma and reflect a more compassionate, evidence-based understanding of substance use health and addiction. Terms that were once commonly used — such as “addict” or “drug abuser” — have been largely replaced with person-first, nonjudgmental language like “people who use drugs” or “person with a substance use disorder.” This shift acknowledges substance use as a health issue rather than a moral failing and helps reduce the discrimination that often prevents individuals from seeking support. The terminology presented here aligns with the current, stigma-reducing approach; however, language continues to evolve, and future changes may further refine how we speak about substance use health to promote dignity and inclusivity. The language used in this report aligned with the Canada’s Drug Agency (CDA-AMC) style guide,⁹ the internal Equity Considerations Resource for CDA-AMC Researchers, and external resources.^{7,9,10}

Acknowledgements

In Partnership

The Canadian Centre on Substance Use and Addiction (CCSA) provides national leadership on substance use health issues and on strengthening public and community safety. Canada’s Drug Agency (CDA-AMC) is a not-for-profit organization responsible for providing Canada’s health care decision-makers with objective evidence to help make informed decisions about the optimal use of drugs and medical devices in the health care system. Recognizing the need for a formal evaluation of drug-checking technologies, CDA-AMC partnered with CCSA to undertake this health technology review, drawing on their complementary areas of expertise. CDA-AMC and CCSA partnered in conceptualization, including development of the objectives and research questions; CDA-AMC led the investigation, methodology, analyses, and writing and editing

the project plan and report; and CCSA facilitated engagement with subject matter experts and provided input on the draft project plan and report. This successful collaboration reinforces the value of interagency partnerships in advancing evidence to support substance use health in Canada.

Peer Reviewers

The authors would like to thank the 2 content experts who externally reviewed this report.

Research Questions

1. What is the accuracy of any drug-checking technologies for detecting compositions of unregulated substance samples?
2. What is the limit of detection, repeatability, and reproducibility of any drug-checking technologies for detecting compositions of unregulated substance samples?
3. What is the cost-effectiveness of any drug-checking technologies for detecting compositions of unregulated substance samples?
4. What are the costs associated with any drug-checking technologies for detecting compositions of unregulated substance samples?

Context and Policy Issues

Drug Toxicity in Canada

The Government of Canada has reported a total of 50,544 deaths related to opioid toxicity between January 2016 and December 2024 (an average of 20 lives per day).⁵ Drug toxicity and related death continue to be declared a public health emergency in several provinces.⁵ The drug toxicity crisis is complex and multifaceted. However, the crisis is driven largely by increasingly toxic, unregulated fentanyl and opioid supplies, particularly when they are contaminated with unexpected, high-potency opioids and other central nervous system and/or respiratory depressants (e.g., benzodiazepine, xylazine).⁵ Of all deaths related to opioid toxicity reported in 2024, 84% involved nonpharmaceutical opioids, 74% involved fentanyl analogues, and 70% involved a stimulant, underscoring the severity of the ongoing emergency.⁵ Hence, many of these deaths involve polysubstance use, with stimulants and benzodiazepines frequently detected alongside opioids. Ontario, Alberta, and British Columbia have experienced the highest numbers of drug-related mortality.⁵ There may be regional differences in drug supply, disparities in service access, and socioeconomic determinants of health that impact the severity of the issue across jurisdictions. The burden of disease related to drug toxicity in Canada is profound, affecting individuals, families, health care systems, and society at large.¹¹ Drug toxicity, particularly from high-potency opioids, has led to a significant loss of life-years and has become 1 of the leading causes of premature death among adults living in Canada.¹¹ In addition to mortality, nonfatal drug toxicity results in substantial morbidity, including brain injury, infectious diseases, and mental health complications.¹² The health care costs associated with emergency responses, hospitalizations,

and long-term care continue to rise, while the broader social and economic impacts include lost productivity and increased demand on social services.¹¹

There is no single solution to the complex and multifaceted nature of the drug toxicity crisis.¹³ People experiencing harms associated with substance use may benefit from access to comprehensive and coordinated services and supports, integrating harm reduction, prevention, treatment, and social supports that put the person and their needs at the centre.¹³ The unpredictable potency and composition of the unregulated fentanyl and opioid supply have prompted calls for harm reduction services and support, such as access to naloxone, supervised consumption sites, and expanded drug-checking services (DCSs), to reduce preventable deaths.¹⁴

What Is Drug Checking?

DCSs are harm reduction services often integrated into community and public health agencies and harm reduction sites, such as substance use services and support programs, supervised consumption sites, mobile harm reduction units, and music and other festivals. Drug-checking technologies (DCTs) are used as part of DCSs to analyze the content of substances that individuals intend to or have consumed, rather than testing biological samples from individuals (e.g., drug testing in blood or urine).² Depending on the method, these technologies may test for the presence of specific substances (such as xylazine) or provide a comprehensive breakdown of the substance's composition, including the various components and their respective concentrations.² Whereas some DCTs can be used directly by people who use drugs (PWUD), DCSs often pair the results with personalized harm reduction advice from front-line health service providers according to the individual's needs.¹⁵ Beyond supporting individual decision-making, by collecting and analyzing unregulated drug samples, DCTs help track trends in the unregulated drug supply and inform public health policies and harm reduction strategies on a broader scale.³ When potentially dangerous substances are identified, DCTs can trigger public health alerts,¹⁶ extending their impact to the wider community of PWUD and service providers. Prompt and accessible drug market monitoring facilitated by robust DCSs can also inform first responders, clinicians, policy-makers, coroners, and researchers of the drug market trends in real time.¹⁷

DCSs can help detect the presence of harmful compositions and unexpected substances, reducing the risk of drug toxicity and related death.¹⁸ These services connect people to settings providing information about the compositions of drugs and the associated risk of their use through a supportive and stigma-free approach.^{17,19} Therefore, they can be particularly helpful for equity-deserving groups such as individuals at high risk of drug toxicity, people without stable housing, and individuals with co-occurring mental illnesses.^{20,21} Evidence suggests that access to DCS supports safer use, facilitates engagement with health and social services, and increases awareness of substance composition.^{16,17} DCSs may also be effective in behaviour change; for example, PWUD may choose to discard harmful substances, use smaller doses or avoid mixing substances, and seek other harm reduction services after drug checking.¹⁶ These results are affected by the population, setting, and the type of substances found in the sample tested.¹⁶

DCTs in Canada

DCTs are increasingly being implemented as a harm reduction tool in response to the ongoing drug toxicity crisis in Canada. These technologies range in complexity from fentanyl test strips (FTS) to more advanced methods, like Fourier transform infrared (FTIR) spectroscopy and mass spectrometry (MS). Learning from European harm reduction efforts, DCSs in Canada began gaining attention in the 1990s. It initially focused on pill testing in rave and festival settings using colorimetric methods. The field expanded further in 2015 with the formation of the National Drug-Checking Working Group (NDCWG) and intensified after the onset of the opioid crisis in 2016.²² Between 2017 and 2019, 3 pilot projects were launched in Canada:

- The British Columbia Centre on Substance Use and the City of Vancouver received support from Health Canada's Substance Use and Addictions Program (SUAP) to test FTIR spectroscopy, demonstrating the feasibility of community DCSs.²³
- Toronto DCS received support from Health Canada's SUAP to pilot an offsite drug-checking model using laboratory-based gas chromatography–mass spectrometry (GC-MS), and high-resolution liquid chromatography–mass spectrometry (LC-MS).¹⁷
- The University of Victoria and Vancouver Island University researchers also received support from Health Canada's SUAP to pilot various DCTs, including FTS, FTIR spectroscopy, GC-MS, Raman spectroscopy, surface-enhanced Raman spectroscopy (SERS), and paper spray–mass spectrometry (PS-MS) to provide real-time harm reduction in Victoria.²⁴

The growing presence of highly potent and toxic substances in the unregulated drug supply and the opioid toxicity crisis have driven the recent expansion of DCSs across Canada.²⁵ From 2020 to 2024, DCSs have increasingly been offered across Canada, with at least 1 service now operating in each of 9 provinces and territories using various technologies.²²

DCSs are offered at fixed sites in the community, such as supervised consumption sites, in mobile units, or at events (e.g., music festivals) across several provinces. While regulatory requirements may vary by province, all DCS operate by way of a section 56 exemption from the federal *Controlled Drugs and Substances Act*.²⁶ These services face challenges related to accessibility, legal frameworks, and standardization across jurisdictions.²²

In Canada, inequitable access to DCSs results from geographic disparities in the availability of DCSs and from limitations associated with how DCSs are structured. Despite the high rates of fatal and nonfatal drug toxicity associated with the use of unregulated drugs across all geographic regions of Canada, nationwide, there is considerable variability in access to DCSs.²⁷ As of 2023, 30 organizations across Canada provide community DCSs, but the number of DCSs in each of Canada's provinces and territories varies widely.²² Access to DCSs in Canada is also concentrated in large urban areas, with limited access in smaller urban areas and rural and remote areas.^{27,28} Additionally, disparities in access to DCSs arise due to limitations associated with how specific DCSs are structured, including limited hours of operation, DCSs being located in areas outside of where PWUD live and/or consume drugs, and the lack of services tailored to the needs of specific demographic groups — including Indigenous Peoples, racialized people, and 2SLGBTQIA+ individuals, in some areas.²⁷

Overview of DCT Outcomes

Different DCTs have varying advantages and limitations depending on the setting in which they are used. There are several types of DCTs, which differ in terms of their analytical techniques, complexity, accuracy, limit of detection (LOD), quantification capabilities, cost, and feasibility.^{18,22,29} For example, some low-cost and rapid tests, such as FTS, offer identification of a limited range of substances but can be useful for quick screening.¹⁴ Midrange technologies, such as FTIR spectroscopy, are more expensive but provide better accuracy and can identify a broader range of substances.¹⁴ Advanced laboratory-based methods, such as GC-MS, LC-MS, quantitative nuclear magnetic resonance (qNMR) spectroscopy, and PS-MS, offer high sensitivity and the ability to quantify substances, but they are more complex and costly to implement.¹⁴ They are also used as reference standards to validate the accuracy of other DCTs and to confirm the presence and concentration of specific substances in samples.^{18,22,29} Based on well-established principles in test accuracy evaluation¹ and harm reduction and DCT literature,³⁰⁻³² previous studies have used several outcomes to evaluate various DCTs in terms of their accuracy, LOD, repeatability, reproducibility, and other considerations (refer to the Key Terminology section for definitions and elaboration for the important terms used throughout this report). In the context of drug checking, certain test accuracy measures may be more critical than others. For example, reporting sensitivity is often prioritized because a false negative (FN) (failing to detect a harmful substance) carries greater risk. Specificity, reflecting the problems with false positives (FP), is also an important outcome to report because FP can generate misinformation about the unregulated drug supply and undermine harm reduction messaging.

Why Is It Important To Do This Review?

Substance use exists on a spectrum that includes abstinence (no use), beneficial use (e.g., prescribed medications used appropriately), lower-risk use, higher-risk use, and addiction (i.e., substance use disorder).⁴ This continuum model underlines the importance of tailoring services and support to an individual's goals and needs, whether they seek to manage, reduce, or eliminate their use.¹⁰

DCTs can be used as a harm reduction and substance use service to determine the content of substances that individuals intend to consume.² DCSs provided at community and public health agencies can also connect individuals to other drug-related, health, and social services and supports according to their needs.¹⁵ Studies have produced evidence on DCTs, including their accuracy, LOD, effectiveness, and harms, as well as implementation guides for setting up DCSs.^{16,18} Notably, the effectiveness of DCSs on the behaviour of PWUD, including intent to use, actual use and disposal of the drug, and outcomes related to models of DCSs (e.g., barriers and facilitators to use), has been addressed in previous studies.¹⁶ There have also been studies on various drug-checking tools and technologies which can specifically respond to issues around the drug supply in Canada.^{22,29} However, there is an identified need for evidence synthesis of various DCTs regarding their accuracy, LOD, and repeatability and reproducibility to detect multiple toxic components at trace levels and unexpected compositions (e.g., carfentanil [a potent fentanyl analogue] in heroin or xylazine and benzodiazepines in fentanyl), in unregulated substance samples and their cost-effectiveness and overall costs along with ethical considerations. In particular, there is a need for summarizing studies that examine the same substance samples using multiple DCTs to better understand specific capabilities and outcomes of various technologies. A comprehensive assessment of DCTs through a customized health technology

review is essential to ensure that these various technologies are equipped to adequately detect unexpected high-potency compositions of unregulated substance samples while balancing costs and ethical and equity considerations for people living in Canada.

Objectives

In response to an external request to support decision-making about DCTs, we prepared this customized health technology review to summarize and, when studies met the criteria for the selected appraisal tools, critically appraised the available evidence about:

- the accuracy of DCTs for detecting compositions of unregulated substance samples
- the LOD, repeatability, and reproducibility of DCTs for detecting compositions of unregulated substance samples
- the cost-effectiveness of DCTs for detecting compositions of unregulated substance samples
- the costs associated with DCTs for detecting compositions of unregulated substance samples.

Methods

An information specialist conducted customized literature searches, balancing comprehensiveness with relevancy, of multiple sources and grey literature on May 26, 2025.

Following Cochrane rapid review methods guidance,³³ at least 2 reviewers were involved in each level of screening citations and selecting studies based on the inclusion criteria presented in [Table 1](#) and critically appraised included studies that met the criteria for appraisal using 2 critical appraisal tools, including the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) checklist³⁴ for test accuracy studies and relevant domains of Drummond checklist³⁵ for cost description studies.

The DCT manufacturers within and outside Canada were identified via search engines, by reviewing DCT literature, and through discussions with DCT experts. Results were reviewed and summarized by 2 reviewers.

[Appendix 1](#) presents a detailed description of methods and selection criteria for included studies. We integrated ethics and equity considerations throughout the report.

Table 1: Selection Criteria

Criteria	Description
Population and setting	Question 1: Substance samples collected from the unregulated drug supplies (e.g., brought in by people who use drugs, submitted by police departments from their unregulated drug samples) Question 2: Any substance sample Questions 3 to 4: Not applicable
Index test or intervention	DCTs for detecting compositions of unregulated substance samples

Criteria	Description
Comparator	No comparator required ^a
Reference standard (as applicable)^b	• Highly sensitive and specific confirmatory lab testing^c • Question 2: Highly sensitive and specific confirmatory lab testing and/or fabricated samples of known composition.
Outcomes^d	Question 1: Accuracy • Sensitivity • Specificity • Positive predictive value • Negative predictive value • True positive • True negative • False positive • False negative Question 2: • Limit of detection • Repeatability • Reproducibility Question 3: Cost-effectiveness (e.g., incremental cost-effectiveness ratio) Question 4: Costs associated with DCTs (e.g., start-up, maintenance, staffing, vendor support)
Study designs	Randomized controlled trials, nonrandomized studies (including test accuracy studies, which may have a single group), economic evaluations, cost descriptions, ^e cost analyses
Publication date	No date limits
Language	English

DCT = drug-checking technology.

^aBased on the request, for questions 1 to 3, we included studies that evaluated more than 1 DCT (at point-of-care, and/or laboratory facilities) on the same substance samples. This should not be confused with comparative test accuracy studies in clinical research, given that the clinical review questions are noncomparative and no comprehensive assessment of comparative bias was conducted.

^bReference standards are particularly used for outcomes including sensitivity, specificity, and limit of detection.

^cHighly sensitive and specific DCTs used to validate the accuracy of other DCTs (i.e., emerging and point-of-care DCTs).

^dThe outcomes of interest were informed by principles in test accuracy evaluation, the DCT literature, and findings of the survey with National Drug-Checking Working Group responses.

^eThe targeted literature search for costing estimates was supplemented by contacting DCT manufacturers to obtain relevant Canadian costing estimates.

Summary of Evidence

Quantity of Research Available

This report includes 20 studies^{23,30,36-53} that met our inclusion criteria, including 19 test accuracy studies and 1 cost description study. Eighteen studies^{23,30,36-51} addressed question 1 (accuracy), 7 studies^{30,36,42,45,46,51,53} addressed question 2 (LOD, repeatability, and reproducibility), and 1 study⁵² addressed question 4 (costs). No studies were identified that addressed question 3 (cost-effectiveness). We reported on the characteristics and results from the included studies.

[Appendix 2](#) presents the PRISMA⁵⁴ flow chart of the study selection.

Summary of Study Characteristics

Summaries of study characteristics are organized by research question. [Appendix 2](#) provides the list of included studies along with the list of excluded studies and the reasons for exclusion. [Appendix 3](#) provides details regarding the characteristics of included studies.

Included Studies for Question 1: Accuracy of Any DCTs for Detecting Compositions of Unregulated Substance Samples

We identified 18 test accuracy studies addressing this question.^{23,30,36-51} Of these, 12 studies examined the accuracy outcomes of more than 1 DCTs against the confirmatory lab testing,^{23,30,36-38,41-43,47,49,50,53} whereas 6 studies^{39,40,45,46,48,51} examined the outcome of 1 DCT against the confirmatory lab testing.

All included studies were cross-sectional studies.^{23,30,36-51} Nine studies^{23,36,37,41-43,47,49,50} were conducted in Canada, 7 studies^{30,38,44-46,48,51} in the US, 1 study³⁹ in Italy, and 1 study in France.⁴⁰

All 18 studies reported 1 or more outcomes on accuracy. Of these, 10 studies reported on sensitivity,^{23,30,36,37,39-42,45,46} 7 studies on specificity,^{23,30,36,40,41,45,46} 3 studies on positive predictive value (PPV) and negative predictive value (NPV),^{23,36,40} 10 studies on true positives (TPs),^{38,47-49,51,55-60} 2 studies on true negatives (TNs),^{38,41} 7 studies on FPs,^{30,38,40,41,43,45,51} 10 studies on FNs,^{23,30,36,40,41,43,45,47,48,51} and 2 studies on concordance (i.e., agreement between the results of 2 tests).^{23,44} In addition to the accuracy outcomes, 1 study also reported outcomes on reproducibility;⁴⁶ however, no included studies reported results on repeatability of DCTs.

Fifteen studies^{23,36-44,47-51} included drug samples submitted by PWUD to various substance use services and supports (e.g., supervised consumption sites, harm reduction settings at night events), 2 studies^{30,45} included drug samples obtained by police departments or law enforcement, and 1 study⁴⁶ included drug paraphernalia residue samples obtained through health departments. Of the included studies, 3 studies^{38,40,44} reported information about the characteristics of participants who provided the substance samples for drug checking.

Fourteen studies^{23,36-44,47,48,50} conducted drug checking at both point-of-care and laboratory facilities, whereas 4 studies^{30,45,46,51} conducted all drug checking of samples exclusively at laboratory facilities. For 13 studies,^{23,30,38-48} all included samples underwent confirmatory lab testing, whereas for 5 studies,^{36,37,49-51} part of the samples that were tested at the point of care also underwent confirmatory lab testing.

Fourteen studies focused on specific target substances in any drug sample:

- fentanyl and its analogues (5 studies)^{23,30,37,38,45}
- benzodiazepine and analogues (5 studies)^{36,41-43,49}
- xylazine (4 studies)^{44,46,48,50}
- synthetic cannabinoid (1 study).⁴⁷

In addition, 2 studies^{39,40} focused on detecting any compositions in the drug samples submitted, whereas the focus of 1 study was on the analysis of 22 illicit drugs and cutting agents.⁵¹

The 18 test accuracy studies reporting on the accuracy of DCTs used the following DCTs as index tests or intervention(s):

- immunoassay test strips (ITS) (16 studies), including FTS (10 studies),^{23,30,37,38,44,45,47,49-51} benzodiazepine test strips (BTS) (4 studies),^{36,41,43,49} and xylazine test strips (XTS) (2 studies)^{46,48}
- FTIR spectroscopy (11 studies)^{23,30,36-38,42-44,47,49,50}
- colorimetric reagent (1 study)³⁹
- portable GC-MS (1 study)⁴²
- hand-held Raman spectrometer (1 study)³⁰
- infrared spectroscopy (IR) spectroscopy (1 study)⁴⁰
- SERS (1 study).⁴¹

All 18 test accuracy studies used highly sensitive and specific DCTs (confirmatory lab testing) as reference standards (some studies used more than 1 type of confirmatory lab testing as their reference standard):

- GC-MS (11 studies)^{23,30,36-39,43,44,47,49,50}
- qNMR spectroscopy (5 studies)^{23,36,37,43,49}
- LC-MS (5 studies)^{36,37,43,47,49}
- liquid chromatography–tandem mass spectrometry (LC-MS-MS) (2 studies)^{45,51}
- liquid chromatography–quadrupole time-of-flight mass spectrometry (3 studies)^{38,44,48}
- PS-MS (2 studies)^{41,42}
- direct analysis in real time mass spectrometry (1 study)⁴⁶
- tandem gas chromatography–mass spectrometry (1 study)⁴⁶
- ultra-performance liquid chromatography–high-resolution mass spectrometry (UPLC-HRMS) (1 study).⁴⁰

Included Studies for Question 2: LOD, Repeatability, and Reproducibility of Any DCTs for Detecting Compositions of Unregulated Substance Samples

We identified 7 test accuracy studies^{30,36,42,45,46,51,53} addressing this question (6 studies^{30,36,42,45,46,51} also addressed outcomes related to research question 1). All were cross-sectional studies^{30,36,42,45,46,51,53} and reported on LOD. Of these studies, 1 study also reported on reproducibility.⁴⁶ Three studies^{36,42,53} were conducted in Canada, and 4 studies^{30,45,46,51} were conducted in the US.

Four studies^{36,42,51,53} included drug samples submitted by PWUD to various substance use services and supports (e.g., harm reduction sites), 2 studies^{30,45} included drug samples obtained by police departments or law enforcement, and 1 study included⁴⁶ drug paraphernalia residue samples obtained through health departments. In 4 studies,^{30,36,42,53} drug checking of some samples was conducted at the point of care and some others at laboratory facilities; in 3 studies,^{45,46,51} all drug checking of samples was conducted at laboratory facilities. For 6 studies,^{30,42,45,46,51,53} all samples underwent confirmatory lab testing, whereas some of the samples of 1 study³⁶ underwent confirmatory lab testing.

Five studies focused on specific target substances in any drug sample:

- fentanyl and its analogues (3 studies)^{30,45,53}
- benzodiazepine and analogues (1 study)³⁶
- xylazine (1 study).⁴⁶

The focus of the other 2 studies was on the detection of carfentanil and etizolam in opioid samples⁴² and the analysis of 22 illicit drugs and cutting agents.⁵¹

Of 7 test accuracy studies^{30,36,42,45,46,51,53} reporting on LOD, the following DCTs were tested:

- ITS (6 studies), including FTS (4 studies),^{30,45,51,53} BTS (1 study),⁵³ and XTS (1 study)⁴⁶
- FTIR spectroscopy (3 studies)³⁰
- portable GC-MS (1 study)⁴²
- hand-held Raman spectrometer (1 study).³⁰

The authors of 1 study reported reproducibility⁴⁶ for XTS.

Three studies used confirmatory lab testing, including qNMR spectroscopy^{36,53} and PS-MS,⁴² as reference standards. Four studies used various concentrations of target substances, including laboratory-grade fentanyl and analogues⁴² and xylazine,⁴⁶ to calculate the minimum cut-off points at which target substances can be consistently detected (i.e., LOD). One study that assessed reproducibility⁴⁶ used pure xylazine as its reference standard.

Included Studies for Question 3: Cost-Effectiveness of Any DCTs for Detecting Compositions of Unregulated Substance Samples

This review did not identify relevant studies that addressed research question 3; therefore, no summary can be provided.

Included Studies for Question 4: Costs Associated With Any DCTs for Detecting Compositions of Unregulated Substance Samples

We identified 1 study⁵² that provided information on the cost of launching and sustaining a community-based drop-in DCS program in Rhode Island, US, from January 2023 to May 2023, which included the implementation of FTIR spectroscopy and FTS at the point of care in addition to confirmatory lab testing. The authors of the study reported that the participants who provided the drug samples were PWUD.

The authors used a microcosting approach to estimate total service costs during the implementation period from a health care payer perspective. All cost inputs required to conduct their drug-checking program were included, regardless of whether they were paid or donated. Unit prices were obtained from various sources, including financial records, itemized bills or receipts, equipment catalogues, and expenditure reports (e.g., salaries and fringe benefits). Program staff were interviewed to estimate the number of hours spent on training, receiving technical assistance and troubleshooting to acquire the required technical expertise for conducting FTIR spectroscopy.⁵² To estimate the cost per drug checked (i.e., unit costs), both fixed (e.g., equipment) and recurrent (e.g., personnel) costs were included.⁵²

Given that the evaluated drug-checking program benefited from in-kind training support and had existing technical expertise in FTIR spectroscopy, a sensitivity analysis was conducted to replace the study's estimated training costs with the assumed training costs to start up such a program if sites do not receive additional government funding or in-kind support.⁵²

Summary of Critical Appraisal

[Appendix 4](#) provides additional details about the risk of bias and applicability of the included studies.

Included Studies for Question 1: Accuracy of Any DCTs for Detecting Compositions of Unregulated Substance Samples

Overall, the test accuracy studies were judged to be at risk of bias: all of the test accuracy studies were assessed as having a high or unclear risk of bias in at least 1 domain, with many studies demonstrating multiple sources of potential bias.^{23,30,36-51} If a study included more than 1 index test, the appraisal conducted and judgment applies to all of them.

Concern regarding applicability was low for all studies,^{23,30,36-51} which indicates that the included samples matched the review question, the index test and its conduct or interpretation were aligned with the review question, and the target condition as defined by the reference standard was consistent with the review question.

Risk of Bias and Applicability in Test Accuracy Studies

All studies^{23,30,36-51} relied on voluntary or convenience sampling methods and were rated as having a high risk of bias in sample selection. There were no applicability concerns about the sample selection for any of the studies: study samples, such as samples submitted by PWUD or law enforcement, aligned with the real-world DCT settings.

Eight studies^{30,36,37,39,43-45,48} were judged to have a low risk of bias for the conduct and interpretation of the index test or intervention, where drug-checking procedures followed standardized protocols and thresholds were clearly prespecified. The remaining 10 studies^{23,38,40-42,46,47,49-51} had high or unclear risk, often due to insufficient reporting on whether index test results were interpreted without knowledge of confirmatory test results and/or without prespecified thresholds or cut-offs. There were no applicability concerns about the index test or intervention for any of the studies, and they all reflected real-world drug-checking practices.^{23,30,36-51}

All studies^{23,30,36-51} used valid and appropriate reference standards (e.g., GC-MS, LC-MS, liquid chromatography–quadrupole time-of-flight MS, PS-MS, qNMR spectroscopy), and concern regarding applicability was low across all studies in this domain. Despite a lack of clarity on knowledge of index test results in most studies, the reference methods were well-established and objective and not likely influenced by index test or intervention results.

Nine studies^{30,39-42,44-46,48} were judged to have a low risk of bias for the flow and timing domain, with appropriate intervals between the index test or intervention and reference testing, and uniform application of

reference standards. In contrast, 9 studies^{23,36-38,43,47,49-51} were judged to have high or unclear risk, often due to partial confirmatory testing or selective inclusion of samples in the confirmatory analysis.

[Table 2](#) presents a summary of the risk-of-bias and applicability assessments for the 18 test accuracy studies.

Table 2: Summary of Risk of Bias in the Included Test Accuracy Studies Using QUADAS-2³⁴

Study citation	Risk of bias ^a					Applicability concerns ^a			
	Sample ^b selection	Index test or intervention		Reference standard	Flow and timing	Sample ^b selection	Index test or intervention		Reference standard
Crepeault et al. (2025) ³⁶	High	BTS	Low	Low	High	Low	BTS	Low	Low
		FTIR	Low				FTIR	Low	
Crepeault et al. (2023) ³⁷	High	FTIR	Low	Low	High	Low	FTIR	Low	Low
		FTS	Low				FTS	Low	
Estrada et al. (2025) ³⁸	High	FTIR	Unclear	Low	High	Low	FTIR	Low	Low
		FTS	Unclear				FTS	Low	
Fregonese et al. (2021) ³⁹	High	Low		Low	Low	Low	Low		Low
Goncalves et al. (2021) ⁴⁰	High	High		Low	Low	Low	Low		Low
Gozdzialski et al. (2022) ⁴¹	High	BTS	High	Low	Low	Low	BTS	Low	Low
		SERS	High				SERS	Low	
Gozdzialski et al. (2021) ⁴²	High	FTIR	High	Low	Low	Low	FTIR	Low	Low
		Portable GC-MS	High				Portable GC-MS	Low	
Green et al. (2020) ³⁰	High	FTIR	Low	Low	Low	Low	FTIR	Low	Low
		FTS	Low				FTS	Low	
		Hand-held Raman spectrometer	Low				Hand-held Raman spectrometer	Low	
Laing et al. (2021) ⁴³	High	BTS	Low	Low	High	Low	BTS	Low	Low
		FTIR	Low				FTIR	Low	

Study citation	Risk of bias ^a					Applicability concerns ^a			
	Sample ^b selection	Index test or intervention		Reference standard	Flow and timing	Sample ^b selection	Index test or intervention		Reference standard
Park et al. (2024) ⁴⁴	High	FTIR	Low	Low	Low	Low	FTIR	Low	Low
		FTS	Low				FTS	Low	
Park et al. (2022) ⁴⁵	High	Low		Low	Low	Low	Low		Low
Sisco et al. (2024) ⁴⁶	High	Unclear		Low	Low	Low	Low		Low
Thompson et al. (2024) ⁴⁸	High	Low		Low	Low	Low	Low		Low
Ti et al. (2021) ⁴⁷	High	FTIR	Unclear	Low	High	Low	FTIR	Low	Low
		FTS	Unclear				FTS	Low	
Ti et al. (2020) ²³	High	FTIR	Unclear	Low	High	Low	FTIR	Low	Low
		FTS	Unclear				FTS	Low	
Tobias et al. (2021) ⁴⁹	High	BTS	Unclear	Low	High	Low	BTS	Low	Low
		FTIR	Unclear				FTIR	Low	
Tobias et al. (2020) ⁵⁰	High	FTIR	Unclear	Low	High	Low	FTIR	Low	Low
		FTS	Unclear				FTS	Low	
Whitehead et al. (2023) ⁵¹	High	FTIR	Unclear	Low	High	Low	FTIR	Low	Low
		FTS	Unclear				FTS	Low	

BTS = benzodiazepine test strips; FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2; SERS = surface-enhanced Raman spectroscopy.

^aIf a study includes more than 1 index test or intervention, the appraisal conducted and judgment made applies to all of them.

^bWe changed the word “patient” in QUADAS-2 to “sample” because the populations studied in this review are substance samples tested using DCTs.

Included Studies for Question 2: LOD, Repeatability, and Reproducibility of Any DCTs for Detecting Compositions of Unregulated Substance Samples

Seven studies^{30,36,42,45,46,51,53} reported LOD outcomes (6 studies^{30,36,42,45,46,51} addressing this question also reported results on accuracy, and 1 study⁵³ reported exclusive outcomes on LOD) and were not appraised with any specific tool, given that there is no known tool for appraising such outcomes. However, key sources of bias and applicability concerns were noted. This study⁵³ exhibited a high risk of bias regarding sample selection, as samples were selected based on convenience or technician suspicion rather than consecutive or randomized sampling, which may have introduced selection bias and limited representativeness of the local drug supply. No major applicability concerns were identified in this domain, given that the study

population (i.e., samples submitted to a supervised consumption site DCS) aligned well with the context of evaluating point-of-care DCTs for harm reduction.

There was a low concern for bias in the application of the index test in the study,⁵³ given that both FTIR spectrometry and FTS were implemented using standardized procedures and commercially available technologies, although thresholds for detection were not prespecified. The reference standard was valid and appropriate, with no applicability concerns; however, blinding to index test results was not explicitly reported.

Regarding flow and timing, the study carried out confirmatory testing on a subset of samples, introducing potential risk of bias due to selective verification and lack of reporting on the time interval between the index test or intervention and the reference testing.⁵³

Included Studies for Question 3: Cost-Effectiveness of Any DCTs for Detecting Compositions of Unregulated Substance Samples

This review did not identify relevant studies that addressed research question 3; therefore, no appraisal can be provided.

Included Studies for Question 4: Costs Associated With Any DCTs for Detecting Compositions of Unregulated Substance Samples

This review identified 1 relevant study that addressed research question 4.⁵² The authors of the cost description study⁵² clearly stated their research question, justified its economic relevance in the context of the opioid crisis, and described with sufficient details the microcosting approach to assess the costs of implementing a point-of-care drug-checking program in Rhode Island, US. The authors clearly described the analytic perspective as that of the payer and the cost categories included reflected this analytical perspective, and the authors specified a short-term time horizon (January 2023 to May 2023), focusing on implementation costs. Costs considered were comprehensive in that they reflected expected costs associated with FTIR spectrometry, FTS, and confirmatory laboratory testing. The authors clearly reported on all assumptions, including the approach to annualize the cost of the FTIR machine given its substantial upfront start-up costs. Sensitivity analyses were conducted that varied the approach to derive training costs using cost ranges. The primary outcome-cost per drug checked was presented with a clear disaggregation of cost components, and the discussion was well supported by the data and accompanied by appropriate caveats.

The generalizability of the findings may be limited to well-supported pilot contexts and may not translate directly to broader health care settings or other jurisdictions. Key model inputs were mainly derived from US data, and differences in drug use patterns, service delivery infrastructure, and the costs associated with implementing point-of-care drug checking between health care systems in the US and Canada could impact the relevance of the cost findings to the context in Canada. Detailed reporting of results was provided on unit costs (e.g., salaries, equipment, training), total costs, and cost per drug checked. Given the transparency with which results are reported, it theoretically could permit the resource amount per drug checked to be calculated. If this value is expected to be similar across settings in Canada and in the US, these values may be transferable to the setting in Canada.

Although the authors refer to their work as a cost analysis, the study could be more accurately described as a cost description, given that it estimates the implementation costs of a single DCT without comparing it to alternative interventions. Several additional considerations could improve the robustness and generalizability of the findings. For example, costs related to the number and type of FTIR libraries purchased were not explored. Given that library expansion may improve the accuracy and sensitivity of drug checking, but at an additional cost, this could significantly affect implementation budgets and limit generalizability to other settings. Moreover, potential long-term maintenance costs such as software updates, calibration, or technical support were not included, likely due to the short time horizon. The study also relied solely on deterministic sensitivity analysis. Incorporating probabilistic methods could have provided more insight into the impact of simultaneous variation in input parameters. While the authors did examine the effect of in-kind training support, which was not found to substantially influence overall costs, this does not account for other plausible implementation scenarios. Finally, although a health care payer perspective is appropriate for many policy decisions, the analysis did not capture potential out-of-pocket or opportunity costs for service users (e.g., transportation), which may be relevant in some public health contexts.

Summary of Findings

[Appendix 5](#) presents additional details regarding the main study findings.

Question 1: Accuracy of Any DCTs for Detecting Compositions of Unregulated Substance Samples

Evidence regarding the accuracy of any DCTs for detecting compositions of unregulated substance samples was available from 18 test accuracy studies.^{23,30,36-51} [Table 3](#) summarizes the test accuracy outcomes (i.e., sensitivity, specificity, and FP and FN rates) of any DCTs for detecting compositions of unregulated substance samples.

Test Accuracy for the Detection of Fentanyl and Analogues

Seven studies^{23,30,37,38,42,44,45} reported on the accuracy of any DCTs for detecting fentanyl and its analogues:

- The sensitivity of:
 - FTS ranged between 87.5% to 100% for detecting fentanyl in 4 studies,^{23,30,37,45} and between 77% to 100% for detecting fentanyl analogues (1 study)³⁷
 - FTIR spectroscopy ranged between 58% and 91% for detecting fentanyl in 4 studies.^{23,30,37,42} FTIR spectroscopy was not sensitive enough to detect carfentanil (i.e., a fentanyl analogue) at relevant concentrations (2 studies)^{37,42}
 - portable GC-MS was 95% for detecting fentanyl and 62% for carfentanil (1 study)⁴²
 - hand-held Raman spectrometers was 61.1% and 38.5% for detecting fentanyl against the confirmatory lab testing in 2 different facilities (1 study).³⁰
- The specificity of:
 - FTS ranged between 89.2% and 98.1% (3 studies)^{23,30,45}
 - FTIR spectroscopy ranged between 90.2% and 99% (2 studies)^{23,30}

- portable GC-MS was not reported⁴²
- hand-held Raman spectrometers was 91.5% and 92.3% against the confirmatory lab testing in 2 different facilities (1 study).³⁰
- The FP rate of:
 - FTS ranged between 1.9% and 10.9% (3 studies)^{23,30,45}
 - FTIR spectroscopy ranged between 1% and 9.3% (2 studies)^{23,30}
 - portable GC-MS was not reported⁴²
 - hand-held Raman spectrometers was 8.5% and 7.7% against the confirmatory lab testing in 2 different facilities (1 study).³⁰
- The FN rate of:
 - FTS ranged between 0% and 12.5% for the detection of fentanyl in 4 studies,^{23,30,37,45} and between 0% and 23% for fentanyl analogues (1 study)³⁷
 - FTIR spectroscopy ranged between 9% and 42% for detecting fentanyl in 4 studies,^{23,30,37,42} and was 100% for detecting fentanyl analogues (2 studies)^{37,42}
 - portable GC-MS was 5% for detecting fentanyl and 38% for carfentanil (1 study)⁴²
 - hand-held Raman spectrometers was 38.9% and 61.5% for detecting fentanyl against the confirmatory lab testing in 2 different facilities (1 study).³⁰
- Other accuracy outcomes:
 - One study⁴⁴ that examined fentanyl detection using FTIR spectrometry and confirmatory lab testing (GC-MS and LC-QTOF-MS) indicated that the results based on samples that tested positive for fentanyl were consistent across the 2 methods (33.9% and 36.8%, respectively) and that they showed a high pairwise concordance (96%).
 - FTS was able to correctly detect 2 fentanyl analogues (acetyl fentanyl and furanyl fentanyl) alone or in the presence of another drug, in both powder and pill forms, in 1 study.³⁰ However, it could not detect carfentanil and several novel fentanyl analogues (e.g., fluorobutyrfentanyl [FBF], fluoroisobutyrfentanyl [FIBF]) at low concentrations in 1 other study.⁴⁵
 - FTIR and Raman spectrometers could produce other relevant information, such as the percentage of fentanyl and the presence of other drugs and cutting agents (1 study).³⁰

Test Accuracy for the Detection of Benzodiazepine and Analogues

The results from 5 test accuracy studies^{36,41-43,49} reported on the detection of benzodiazepine and its analogues:

- The sensitivity of:
 - BTS ranged between 8% and 100% (4 studies);^{36,41,43,49} the relatively low sensitivity (8%) in 1 study⁴¹ was attributed to limitations of BTS in trace detection of etizolam in opioids
 - FTIR spectroscopy ranged between 8.3% and 26% (4 studies)^{36,42,43,49}

- BTS and FTIR combined was 70.8% and 75% (2 studies)^{36,43}
- portable GC-MS was 36% in all samples and 78% in samples with concentrations of more than 3% (1 study)⁴²
- SERS was 96% (1 study).⁴¹
- The specificity of:
 - BTS ranged between 67% and 100% (4 studies)^{36,41,43,49}
 - FTIR spectroscopy ranged between 96.1% and 100% (3 studies)^{36,43,49}
 - BTS and FTIR combined was 82% and 82.2% (2 studies)^{36,43}
 - portable GC-MS was not reported⁴²
 - SERS was 86% (1 study).⁴¹
- The FP rate of:
 - BTS ranged between 0% and 33% (4 studies)^{36,41,43,49}
 - FTIR spectroscopy ranged between 0% and 3.9% (3 studies)^{36,43,49}
 - BTS and FTIR combined was 17.8% and 18% (2 studies)^{36,43}
 - portable GC-MS was not reported⁴²
 - SERS was 14% (1 study).⁴¹
- The FN rate of:
 - BTS ranged between 0% and 92% in (4 studies)^{36,41,43,49} the relatively high FN rate (92%) in 1 study⁴¹ was attributed to the limitations of BTS in trace detection of etizolam in opioids
 - FTIR spectroscopy ranged between 74% and 91.7% (4 studies)^{36,42,43,49}
 - BTS and FTIR combined was 25% and 29.2% (2 studies)^{36,43}
 - portable GC-MS was 64% in all samples and 22% in samples with concentrations of more than 3% (1 study)⁴²
 - SERS was 4% (1 study).⁴¹

Test Accuracy for the Detection of Xylazine and Analogues

The results from 4 test accuracy studies^{44,46,48,50} reported on the detection of xylazine:

- The sensitivity of:
 - XTS was 22.2% and 97.4% (2 studies)^{46,48} the relatively low sensitivity (22.2%) in 1 study⁴⁸ was attributed to limitations of XTS in trace detection of xylazine, given that its sensitivity increased to 100% when xylazine was a major active component of the tested sample⁴⁸
 - FTIR spectroscopy was 0% (i.e., unable to detect xylazine) and 54% (2 studies).^{44,50}
- The specificity of:
 - XTS was 100% (2 studies)^{46,48}
 - FTIR spectroscopy was not reported (2 studies).^{44,50}

- The FP rate of:
 - XTS was 0% (2 studies)^{46,48}
 - FTIR spectroscopy was not reported (2 studies).^{44,50}
- The FN rate of:
 - XTS was 2.6% and 77.8% (2 studies);^{46,48} the relatively high FN rate (77.8%) in 1 study⁴⁸ was attributed to the limitations of XTS in trace detection of xylazine.
 - FTIR spectroscopy was 46% and 100% (2 studies).^{44,50}

Test Accuracy for the Detection of Other Compositions

Two studies^{39,40} reported the accuracy of DCTs for detecting any compositions in drug samples submitted for drug checking. The additional 2 studies reported on the analysis of 22 illicit drugs and cutting agents⁵¹ and on synthetic cannabinoid compounds.⁴⁷

- One study³⁹ indicated that colorimetric reagents had a moderate to high sensitivity (ranging between 78% and 100%) with regard to samples being contaminated (e.g., LSD, amphetamine) or samples with very a small quantity; however, colorimetric reagents failed to identify drug mixtures (with approximately equal presentation of different drugs) and methamphetamine samples identified using the confirmatory lab testing (GC-MS analysis) and the contaminant present in them.
- One study⁴⁰ that examined the sensitivity and specificity of IR spectroscopy against confirmatory lab testing (LC-QTOF) indicated that IR spectrometry showed high sensitivity (ranged between 82.4% to 100%), and low FN rates (ranged between 0% to 17.6%), with the exception of heroin, and high specificity (100%) for detection of all main substances (i.e., cocaine, 3,4-methylenedioxymethamphetamine (MDMA), heroin, and amphetamine).
- One study⁵¹ that focused on the analysis of 22 illicit drugs and cutting agents showed that FTS has a high sensitivity (95%) and specificity (100%), low FN rates (i.e., 5%), and no record of FPs.
- One study⁴⁷ that assessed the FN rate and sensitivity of FTIR spectroscopy against confirmatory lab DCTs (GC-MS or LC-MS) for detecting the synthetic cannabinoid compounds showed that FTIR spectroscopy had a sensitivity of 52% and FN rate of 48%.

Table 3: Summary of Findings for the Test Accuracy of Any DCTs for Detecting Compositions of Unregulated Substance Samples

Index test(s) or intervention(s) (studies), N	Source of sample, country	Confirmatory lab testing	Sensitivity, %	Specificity, %	FP rate, %	FN rate, %
Fentanyl and analogues						
FTS ^{23,30,37,45} (4 studies)	PWUD, ³⁷ Canada	qNMR, GC-MS, or LC-MS	Fentanyl: 94 ^{ab} Fentanyl analogues: 77 to 100 ^c	NR	NR	Fentanyl: 6 ^{ab} Fentanyl analogues: 0 to 23 ^c
	Law enforcement, ³⁰ US	GC-MS	96.3 ^d and 100 ^e	90.4 ^d and 98.1 ^e	9.6 ^{ad} and 1.9 ^{ae}	3.7 ^{ad} and 0 ^{ae}
	Law enforcement, ⁴⁵ US	LC-MS-MS	98.5	89.2	10.9	1.5
	PWUD, ²³ Canada	qNMR, GC-MS	87.5	95.2	4.8 ^a	12.5
FTIR ^{23,30,37,42} (4 studies)	PWUD, ³⁷ Canada	qNMR, GC-MS, or LC-MS	Fentanyl: 58 Fentanyl analogues: 0	NR	NR	Fentanyl: 42 Fentanyl analogues: 100
	Law enforcement, ³⁰ US	GC-MS	83.3	90.2	9.3 ^a	16.7 ^a
	PWUD, ²³ Canada	qNMR, GC-MS	72.1	99	1 ^a	27.9
	PWUD, Canada ⁴²	PS-MS	Fentanyl: 91 Carfentanil: 0	NR	NR	Fentanyl: 9 ^a Carfentanil: 100 ^a
Portable GC-MS ⁴² (1 study)	PWUD, Canada	PS-MS	Fentanyl: 95 Carfentanil: 62	NR	NR	Fentanyl: 5 ^a Carfentanil: 38 ^a
Hand-held Raman spectrometer ^{30,f} (1 study)	Law enforcement, US	GC-MS	61.1 ^d and 38.5 ^e	91.5 ^d and 92.3 ^e	8.5 ^{ad} and 7.7 ^{ae}	38.9 ^{ad} and 61.5 ^{ae}
Benzodiazepine and analogues						
BTS ^{36,41,43,49} (4 studies)	PWUD, ³⁶ Canada	qNMR, GC-MS, LC-MS	67	82	18 ^a	33 ^a
	PWUD, ⁴¹ Canada	PS-MS	8	100	0 ^a	92 ^a

Index test(s) or intervention(s) (studies), N	Source of sample, country	Confirmatory lab testing	Sensitivity, %	Specificity, %	FP rate, %	FN rate, %
	PWUD, ⁴³ Canada	GC-MS, LC-MS, qNMR	62.5 ^a	84.5 ^a	15.5	37.5
	PWUD, ⁴⁹ Canada	GC-MS	100 ^a	67 ^a	33 ^a	0 ^a
FTIR ^{36,42,43,49} (4 studies)	PWUD, ³⁶ Canada	qNMR, GC-MS, LC-MS	26	99	1 ^a	74 ^a
	PWUD, ⁴² Canada	PS-MS	9	NR	NR	91 ^a
	PWUD, ⁴³ Canada	GC-MS, LC-MS, qNMR	8.3 ^a	96.1 ^a	3.9	91.7
	PWUD, ⁴⁹ Canada	GC-MS	17 ^a	100 ^a	0 ^a	83 ^a
BTS and FTIR combined ^{36,43} (2 studies)	PWUD, ³⁶ Canada	qNMR, GC-MS, LC-MS	75	82	18 ^a	25 ^a
	PWUD, ⁴³ Canada	GC-MS, LC-MS, qNMR	70.8 ^a	82.2 ^a	17.8	29.2
Portable GC-MS ⁴² (1 study)	PWUD, Canada	PS-MS	36 ^g and 78 ^h	NR	NR	64 ^{ag} and 22 ^{ah}
SERS ⁴¹ (1 study)	PWUD, Canada	PS-MS	96	86	14 ^a	4 ^a
Xylazine and analogues						
XTS ^{46,48} (2 studies)	Drug residue, ⁴⁶ US	DART-MS, GC-MS-MS	97.4	100	0 ^a	2.6 ^a
	Drug residue, ⁴⁸ US	LC-QTOF-MS	22.2	100	0	77.8
FTIR ^{44,50} (2 study)	PWUD, ⁵⁰ Canada	GC-MS	0 ^a	NR	NR	100 ^a
	PWUD, ⁴⁴ US	GC-MS, LC-QTOF-MS	54 ^a	NR	NR	46 ^a

Index test(s) or intervention(s) (studies), N	Source of sample, country	Confirmatory lab testing	Sensitivity, %	Specificity, %	FP rate, %	FN rate, %
Other drug compositions						
FTS ^{51,i} (1 study)	PWUD, US	LC-MS-MS	95 ^a	100 ^a	0	5
Colorimetric reagents ³⁹ (1 study)	Night event attendees, Italy	GC-MC	Ketamine: 78 MDMA: 84 Amphetamine: 91 Cocaine: 92 Heroin: 88 LSD: 100 Mephedrone: 0 MIX: ^j 0 Debris: ^k 0 Methamphetamine: 0	NR	NR	Ketamine: 22 ^a MDMA: 16 ^a Amphetamine: 9 ^a Cocaine: 8 ^a Heroin: 12 ^a LSD: 0 ^a Mephedrone: 100 ^a MIX: ^j 100 ^a Debris: ^k 100 ^a Methamphetamine: 100 ^a
IR spectroscopy ⁴⁰ (1 study)	PWUD, France	LC-QTOF-MS	Cocaine: 100 MDMA: 86.8 Amphetamine: 82.4 Heroin: 50 Caffeine: 63.2 Paracetamol: 84.6	Cocaine: 100 MDMA: 100 Amphetamine: 100 Heroin: 100 Caffeine: 100 Paracetamol: 100	Cocaine: 0 ^a MDMA: 0 ^a Amphetamine: 0 ^a Heroin: 0 ^a Caffeine: 0 ^a Paracetamol: 0 ^a	Cocaine: 0 MDMA: 13.2 Amphetamine: 17.6 Heroin: 50 Caffeine: 36.8 ^a Paracetamol: 15.4 ^a
Synthetic cannabinoid contamination						
FTIR ⁴⁷ (1 study)	PWUD, Canada	GC-MS, LC-MS	52 ^a	NR	NR	48

BTS = benzodiazepine test strips; DART-MS = direct analysis in real time mass spectrometry; DCT = drug-checking technology; FN = false negative; FP = false positive; FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; GC-MS-MS = gas chromatography–tandem mass spectrometry; IR = infrared spectroscopy; LC-MS = liquid chromatography–mass spectrometry; LC-MS-MS = high-precision liquid chromatography–tandem mass spectrometry; LC-QTOF-MS = liquid chromatography quadrupole time-of-flight mass spectrometry; LSD = lysergic acid diethylamide; MDMA = 3,4-methylenedioxymethamphetamine; NR = not reported; PS-MS = paper spray–mass spectrometry; PWUD = people who use drugs; qNMR = quantitative nuclear magnetic resonance; SERS = surface-enhanced Raman spectroscopy; XTS = xylazine test strips.

^aCalculated by authors of this report based on the available data in the included studies.

^bThe authors of this study reported a portion of the FTS and FTIR results (i.e., 801) for all positives obtained by the confirmatory lab testing (i.e., 855). We calculated the sensitivity and FNs based on 801 samples that were explicitly reported in the study.

^cLowest and highest sensitivity and FN rates identified for examining various types of fentanyl analogues.

^dSensitivity and specificity of the FTS against the confirmatory lab testing in the Rhode Island laboratory.

^eSensitivity and specificity of the FTS against the confirmatory lab testing in the Baltimore laboratory.

^fResults reported here are related to the Raman spectrometer SERS kit. For results reported on the Raman spectrometer point-and-shoot mode, please refer to [Table 26](#).

^gSensitivity calculated in all samples.

^hSensitivity calculated in samples with concentrations of more than 3%.

ⁱIn this study,⁵¹ FTS are used in the context of testing any drugs, and not specifically fentanyl as the target composition. This study also used BTS, but the author stated that “a comparison of the results from BTS to LC-MS-MS could not be made because all samples but 1 tested negative on BTS. For the one sample that showed a positive BTS, none of the 4 benzodiazepines included in this LC-MS-MS method were quantified in that sample.” This information is available in [Table 29](#).

^jMIX: samples with mixtures of substances, in which the substances were present in approximately equal quantities and had similar pharmacological activities.

^kDebris: a sample that was found to be free of active substances.

Question 2: LOD, Repeatability, and Reproducibility of Any DCTs for Detecting Compositions of Unregulated Substance Samples

Limit of Detection

Seven test accuracy studies^{30,36,42,45,46,51,53} reporting on LOD of DCTs:

- Two studies^{36,53} that tested the LOD of ITS (FTS and BTS) and FTIR spectroscopy against confirmatory lab testing (qNMR spectroscopy) indicated that FTS and BTS were able to detect the presence of fentanyl and benzodiazepines in samples at concentrations between 2% and 5%. The LOD of FTIR spectroscopy in both studies was reported to be more than 10%.
- Two studies^{45,51} that evaluated the LOD of FTS using laboratory-grade fentanyl and high-priority fentanyl analogues found the LOD to be 100 ng/mL⁵¹ and 200 ng/mL⁴⁵ for fentanyl and 1,000 ng/mL or less⁴⁵ for 13 analogues (among 17 analogues tested).
- One study⁴⁶ that examined the LOD of XTS using pure xylazine laboratory samples found a low LOD of 2.5 mcg/mL or more (2,500 ng/mL).
- One study⁴² that examined the LOD of portable GC-MS and FTIR against PS-MS found that, at concentrations of more than 3%, the portable GC-MS was able to detect 78% of the etizolam samples that were confirmed by PS-MS, whereas its LODs for the detection of carfentanil was between 0.13% and 0.63% by weight. The LOD of FTIR for detection of samples containing etizolam was not clearly stated. In addition, FTIR was not able to detect samples containing carfentanil that were detected by PS-MS.
- One study³⁰ that examined the LOD of FTS, hand-held Raman, and FTIR spectrometers, and GC-MS using powder fentanyl standards as reference, found LODs of 0.100 mcg/mL, 3.1 mcg/mL, 3% to 4% by weight, and 25 mcg/mL for FTS, GC-MS, FTIR spectroscopy, and hand-held Raman spectrometer, respectively.

Repeatability

We did not identify any study that reported results on the repeatability of DCTs.

Reproducibility

One test accuracy study⁴⁶ that examined the reproducibility for XTS, including consistency of results across days (2 tests per day) over a 6-week period and consistent detection near LOD, indicated that the XTS consistently produced clear positive results with the 5,000 mcg/mL xylazine solution, and clear negative results with xylazine-free water. The approximate LOD, where consistent positive results could be obtained, was found to be 2.5 mcg/mL (2,500 ng/mL).⁴⁶

Question 3: Cost-Effectiveness of Any DCTs for Detecting Compositions of Unregulated Substance Samples

We found no relevant evidence regarding the cost-effectiveness of any DCTs for detecting compositions of unregulated substance samples; therefore, no summary can be provided.

Question 4: Costs Associated with Any DCTs for Detecting Compositions of Unregulated Substance Samples

The findings from 1 cost description study⁵² that was conducted from a payer perspective in the US, indicated that the total cost of establishing and operating a DCS pilot was US\$71,044 and the cost per drug checked was US\$474, including confirmatory lab testing (US\$150 per sample). More than half (approximately 54%) of this cost was attributed to the FTIR machine, software, libraries, and technical training.

Sensitivity analyses indicated that the cost could increase to between US\$78,058 and US\$83,058, or US\$544 to US\$593 per sample checked, for programs needing to pay for at-cost training supports, including specialized training in FTIR spectroscopy.⁵² The study authors further estimated that real-world implementation may require 10% to 25% of samples to be checked for ongoing quality assurance, which would increase costs. It is noteworthy that this study was conducted from January 2023 to May 2023 and the costs may fluctuate from 1 year to another; their costing represents the first year of program implementation. We note that prices are expected to vary based on the number of tests conducted, given that costs substantially decrease with higher testing volumes.

Summary of DCT Manufacturer Information

[Table 4](#) provides a consolidated summary of findings, and [Appendix 6](#) presents the detailed findings from surveys completed by DCT manufacturers.

We identified and contacted 21 DCT manufacturers within and outside Canada. Of these, 18 responded and were sent a series of questions via a survey about their respective DCTs, including costs and capabilities (e.g., portability, time to result). Of those manufacturers, 11 completed 16 independent surveys related to different types of DCTs (i.e., certain manufacturers sell more than 1 relevant DCT).

The responses include information about the following DCT types:

- ITS (2 manufacturers)
- Raman, infrared (IR), and near-infrared DCTs (6 manufacturers)
- Mass spectrometry (MS) DCTs (3 manufacturers, 1 overlap with the previous group)

Among the survey data received, 4 DCTs were for technologies included in the test accuracy studies:

- 1 manufacturer produces ITS that were evaluated in 14 studies;^{30,36,37,41,43-51,53}
- 1 manufacturer provided information on LC-MS that was evaluated in 1 test accuracy study;⁴⁵ and
- 1 manufacturer provided information on FTIR spectrometer that were reportedly used in 10 studies,^{30,36-38,43,44,47,49,50,53} and related to IR stereoscopy which was reportedly used in 1 study.⁴⁰

Of 11 manufacturers who responded to the survey, 4 are Canadian, and 2 of the 7 international manufacturers have office locations in Canada. All the international manufacturers sell to buyers outside their country.

Immunoassay Test Strips

Two manufacturers of ITS responded to our survey. These ITS can detect substances, including fentanyl, xylazine, benzodiazepines, medetomidine, and nitazenes, typically within a few minutes. These strips are

low-cost (i.e., a few dollars per strip depending on the type and quantity) and do not require any ongoing operational costs. These strips are designed for “lay users” (nonexperts), are highly portable, and can be widely used in community-based settings (e.g., mobile harm reduction vans).

Raman, Infrared, and Near-Infrared Technologies

We received 7 completed surveys from 6 manufacturers for this category, including:

- 2 manufacturers of FTIR;
- 3 manufacturers of SERS and Raman Spectroscopy (1 completed 2 surveys on 2 different models); and
- 1 manufacturer of near-infrared spectroscopy.

Their time to results ranges from a few seconds to 15 minutes. These DCTs were reported to be at a midrange cost. In most cases, the manufacturers reported that services, including software updates, database or library upgrades, online support, and a limited-time warranty, are included in the purchase price. All manufacturers reported no or minimal ongoing operational costs (e.g., consumables, reagents, test cartridges, maintenance) for these devices. All manufacturers provide remote and/or onsite DCT servicing as required and access to DCT support by phone and email. Expected service and maintenance costs were reported to be \$0 or nominal for all devices. The training and qualification required for operating these devices vary from minimal to basic knowledge around FTIR spectroscopy, spectral interpretation, sampling preparation, and optimization. Except for 1 FTIR device, these devices were reported as portable and can be used outdoors and in a vehicle. Except for the FTIR device, other manufacturers recommended using ITS in combination with their technologies for the detection of small quantities and specific substances (ITS must be purchased separately).

MS Technologies

We received 7 completed surveys from 3 manufacturers of different types of MS technologies, including:

- 1 from a manufacturer of a Mini MS (small size and portable)
- 1 from a manufacturer of direct ionization MS
- 5 from a manufacturer of high-resolution LC-MS and GC-MS, triple quadrupole LC-MS and GC-MS, and an ion source paper spray mass spectrometry (PS-MS).

The time required for these DCTs to provide results ranges from 1 to 20 minutes, depending on the device. These DCTs were at the highest price range; however, in most cases, other expenses such as software updates or database or library upgrades, perpetual licence, online support, shipping, installation, familiarization, limited-time warranty, as well as onsite training of staff in 1 case were included in the purchase price. All provide remote and onsite DCT servicing as required, service and maintenance support based on the warranty or contract, and technical or user support included in the base purchase price. The training and qualification required for operating these devices vary from minimal to knowledge around running analytical instrumentation (MS is preferred, related to either GC or LC). One device can be used outdoors, and 2 devices can be used in a vehicle. Manufacturers reported there is no need to use ITS in combination with these DCTs.

Table 4: Consolidated Findings From Surveys With DCT Manufacturers

Features	Immunoassay test strips	Raman spectroscopy or infrared and near-infrared spectroscopy	Mass spectrometry
Survey respondents	2 manufacturers: 1 from Canada, 1 international	6 manufacturers: 3 from Canada, 3 international 7 surveys: 2 FTIR, 4 Raman and SERS, 1 NIS	3 manufacturers: 3 international 7 surveys: 1 Mini MS, 1 direct ionization MS, 5 on High-Res Orbitrap LC/GC-MS, TSQ LC/GC-MS, and PS-MS
Time to results	< 5 minutes	- Raman and NIS: 5 seconds to 15 minutes - FTIR: < 2 minutes	- Mini MS: < 3 minutes - Direct ionization MS: 1 minute - Other MS: 5 to 20 minutes
Pricing and fees	- Low (a few dollars per strip) - Bulk discounts available - No ongoing operational costs	- Midrange - Some bulk discount, financing, and rental options available - No or minimal ongoing operational costs - Annual licence fees for 2 Raman and NIS devices	- High - Some bulk discount, financing, and rental options available - Some ongoing operational costs required - No annual licence fees for 1; other 2 not reported
Servicing and support	Free technical support through phone calls, email, and talking to agent (reported for 1)	- Included in purchase for most devices: - Software and database updates - Warranty - Phone, email, and onsite support	- Included in purchase for most devices: - Software/database updates - Warranty - Installation and training - Phone, email, and onsite support
Training and staffing	None (“lay user” [nonexpert] friendly, package instructions)	1 requires no training - Others need Windows proficiency, safety training, or FTIR knowledge - Virtual or in-person training available (2 require additional fees)	2 require limited training - Others require MS expertise (onsite training often included)
Portability and infrastructure needs	- Highly portable and durable (outdoors/vehicles) - Suitable for point of care	- Portable and durable (outdoors/vehicles), except for 1 FTIR - Suitable for point of care	- Not portable or durable, except for 1 - Suitable for confirmatory lab testing 1 can be used at point of care
ITS compatibility	NA	Often recommended in combination with ITS (sold separately)	Not required

FTIR = Fourier transform infrared; ITS = immunoassay test strips; LC/GC-MS = liquid chromatography/gas chromatography–mass spectrometry; MS = mass spectrometry; NA = not applicable; NIS = near-infrared spectroscopy; PS-MS = paper spray mass spectrometry; SERS = surface-enhanced Raman spectroscopy; TSQ = triple stage quadrupole.

Limitations

Evidence Gap

There is a significant evidence gap in drug-checking research, particularly regarding the accuracy, LOD, cost-effectiveness, and real-world performance of different DCTs.^{44,48} This review did not find any study that met the inclusion criteria of reporting results on the repeatability of DCTs. Many studies rely on small-scale pilots, limiting the generalizability of their findings to diverse and evolving drug markets.⁴⁸ Research often focuses on the detection of a narrow and specific range of substances (e.g., fentanyl, benzodiazepines), with limited evaluation of emerging synthetic analogues and complex and ultra-high-potency mixtures (e.g., nitazenes, highly potent opioid analogues).³⁶ There is also a need for more studies on the accuracy and other outcomes of many emerging DCTs and the multimethod approaches for drug checking (i.e., combining different DCTs for drug checking). Furthermore, there is a lack of standardized outcome measures and consistent reporting of sensitivity, specificity, and FN and FP rates in the studies evaluating DCTs, making cross-study comparisons challenging. Many studies are conducted as pilot projects or conducted with limited or nonrepresentative samples of the local drug market, which may not accurately reflect the complexity of evolving unregulated drug markets. Robust, large-scale studies that evaluate the effectiveness of multimethod approaches are needed.⁴⁸

This review concentrated on the technical performance and evaluation of DCTs. A key limitation of inconsistent evidence on the accuracy of DCT is the potential for FNs and FPs. FNs that allow highly potent and toxic substances to go undetected may create a false sense of safety among PWUD, potentially increasing the likelihood of use or higher-risk consumption.^{36,39,44} Additionally, FP are also highly problematic, as they can generate misinformation about the unregulated drug supply and undermine harm reduction messaging — for example, by reinforcing myths that fentanyl is present in all substances. While most studies focus on detecting the presence or absence of target substances, less attention has been given to the assessment of the concentration of those detected substances. Yet, concentration levels are of significant interest and concern for regional health authorities and their community partners because they have implications for both individual and public health risk and may necessitate the use of different tools depending on the setting and purpose of testing. These limitations may undermine the harm reduction intent of DCT and highlight the need for clear communication about the technologies' limitations, including their detection thresholds and the possibility of undetected or misidentified compositions.³⁶

Another limitation in the existing literature is that the definition of DCTs often focuses exclusively on the hardware of the device (e.g., spectrometer or test kit) without adequately considering the software components that process, interpret, or visualize the resulting data. This narrow framing overlooks how software contributes to the accuracy, usability, and adaptability of these technologies. In many cases, these software tools — whether embedded in the device or external analysis programs — play a critical role in determining the sensitivity and specificity of the technology. Different software systems can employ distinct algorithms, databases, or update schedules, which may lead to variations in how substances are identified and reported. Even for devices with onboard software, differences between versions can influence performance, as updates may modify reference libraries or analytical algorithms. However, these distinctions

are rarely reported or evaluated in the current literature, making it difficult to compare results across studies or over time. Furthermore, the literature has not yet addressed the growing interest in applying machine learning approaches to enhance drug analysis, which represents an important gap in understanding future directions for the field.

Additional research to better integrate the priorities and needs of PWUD into program development and evaluation would be of benefit. DCSs are most effective when they are designed and evaluated in collaboration with PWUD because their insights are critical for understanding real-world barriers to access, trust in testing results, and the usability of different technologies. These perspectives provide key contextual factors such as how results are interpreted; whether technologies meet the needs of diverse groups; and the role of stigma, criminalization, or cultural safety in shaping service uptake.

This review did not identify any relevant evidence regarding the cost-effectiveness of DCTs for detecting compositions of unregulated substance samples. This limits the ability to evaluate their economic value. Without evidence on costs relative to health and/or social outcomes, policy-makers face challenges in how to allocate scarce resources and how to prioritize DCT implementation over other interventions. This gap also hinders the development of funding models and scalability plans because the return on investment and potential health care savings (e.g., reduced drug toxicity and related death, hospitalizations) remain unclear.

One cost description study⁵² was identified that may have limited generalizability to the setting in Canada. Given that this was a pilot program that reflected on establishing and operating a DCS in the US over 9 months (of which 3 months were operational for drug checking), the long-term sustainability within harm reduction and public health programs remains unknown. The DCT manufacturers we surveyed provided some of the information regarding the costs (e.g., upfront and ongoing costs, staff training requirements, and manufacturer support) and capabilities (e.g., portability, time to result) of various DCTs. However, other cost implications, such as the cost associated with implementing and maintaining a drug-checking program within comprehensive substance use services and support, in particular in the context in Canada, remain largely unanswered. While the scope of our costing exercise mostly focused on device-related costs, it is important to note that there may be other implementation costs that have not been considered (e.g., facility costs, labour costs). While we acknowledge that the costs of implementing and scaling a lab-based drug-checking program for regional health authorities and their community partners may be prohibitive (i.e., costs are so high that they prevent or severely limit something from happening), emerging DCTs are specifically intended to help overcome some of these financial and resource barriers (refer to the Emerging Technologies section).

Generalizability

The generalizability of findings from drug-checking studies is often limited due to variations in sample types, testing conditions, limited collection radius and time frame, and the nonrandom nature of the collection procedure.^{37,44,48} Some of the evaluations are conducted in controlled laboratory settings or focus on specific substances, which may not reflect the complexity and variability of real-world drug markets.⁴⁸ Regional differences in drug supply, prevalence of contaminants, and service use and specific needs of PWUD further challenge the applicability of study results to other settings.^{36,37} Additionally, the performance of technologies,

such as FTIR spectroscopy, FTS, or portable GC-MS, can vary depending on drug form, concentration, and matrix, making it difficult to generalize findings to broader populations or contexts.^{41,42}

Out of 20 included studies, 10 studies,^{30,38-40,44-46,48,51,52} including 1 cost description,⁵² were conducted in countries other than Canada. The generalizability of the findings to settings in Canada may be limited due to differences in health care systems (e.g., point of care, harm reduction infrastructure), regulatory frameworks, and characteristics of the unregulated drug supply compared to the settings where the studies were conducted.

It should also be acknowledged that the field of drug checking is relatively new. While technologies such as FTIR and GC-MS have long been used in laboratory settings with well-established evidence to support their application, there is limited evidence regarding their use in community settings with the unregulated drug supply. Further research is needed to strengthen the evidence base through efforts such as field testing of unregulated drug supply in real-world contexts, such as DCSs or music festivals.²⁹

Heterogeneity of the Evidence

The evidence on DCTs is highly heterogeneous, reflecting substantial variability in the substances tested and the performance metrics reported.^{37,48} Different DCTs, such as FTIR spectroscopy, FTS, and colorimetric tests, are evaluated under diverse conditions, with varying confirmatory lab testing like GC-MS or LC-MS-MS. Sensitivity, specificity, and FP and FN rates are inconsistently measured and reported, making direct comparisons between studies challenging.³⁹ This heterogeneity limits the ability to synthesize results into clear conclusions about the accuracy of DCTs across settings.

Conclusions and Implications for Decision- or Policy-Making

This review evaluated the literature regarding accuracy, LOD, repeatability, and reproducibility, cost-effectiveness, and cost associated with DCTs for detecting compositions of unregulated substance samples. We identified 18 test accuracy studies^{23,30,36-51} on accuracy, 7 studies^{30,36,42,45,46,51,61} on LOD, and 1 study⁴⁶ on reproducibility of any DCTs for detecting compositions of unregulated substance samples. We did not find any study on the repeatability of DCTs that meet the review's inclusion criteria. We found 1 cost description study⁵² reporting on the costs of DCTs. We found no relevant evidence regarding the cost-effectiveness of any DCTs for detecting compositions of unregulated substance samples. The context of DCTs also raises several ethics and equity considerations that are critical to the design and implementation of DCTs and DCSs.

Summary of Evidence

This review provides a synthesis of the current evidence on the accuracy, LOD, and reproducibility and cost associated with DCTs, highlighting both their strengths and limitations. The findings reinforce that although certain technologies, such as FTS and SERS, demonstrate high sensitivity for detecting target substances like fentanyl and benzodiazepine analogues, other commonly used methods like FTIR spectroscopy and colorimetric tests show more variable accuracy, especially in detecting low-concentration compounds,

complex mixtures, and emerging synthetic analogues. However, a challenge with ITS is their narrow focus on 1 target substance and their potential issues with cross-reactivity (i.e., they provide positive results for most fentanyl analogues and do not provide in-class drug discrimination and quantitative data). In practice, broader-spectrum technologies can help identify overall trends and contaminants in the drug supply, while targeted tools such as ITS can be deployed in settings closer to PWUD (e.g., festivals or supervised consumption sites) to rapidly detect priority substances of immediate concern. The review adds value by summarizing recent data on validated and emerging DCTs and indicating that using multimethod approaches (e.g., combining FTIR spectroscopy with ITS) can improve detection accuracy and reliability in harm reduction settings. This finding was consistent with the findings from our survey with the manufacturers of Raman, IR, and near-infrared technologies, which recommended using ITS in combination with their technologies to detect small quantities and specific substances. However, there remains considerable uncertainty due to limited studies on the evaluation of combined DCTs, heterogeneity in reported results, and reliance on small samples, which limit the generalizability and strength of conclusions.

Significant gaps persist in the published evidence, particularly regarding the cost-effectiveness and costs of these technologies in real-world contexts.³⁷ Despite our review's intention to address economic evaluations, no evidence was found on cost-effectiveness or resource implications. As a first step in understanding the costing implications of these technologies, we obtained cost information from DCT manufacturers. However, in comparing this cost description study³⁷ with the information obtained directly from manufacturers, several differences emerged. While manufacturers provided baseline costing information for devices, consumables, and training, the study incorporated additional operational factors such as confirmatory lab testing and quality assurance protocols, which substantially increased overall costs. Together, these complementary sources highlight both the direct and downstream costs of DCT implementation, underscoring the importance of considering real-world operational requirements beyond device acquisition alone.

This review did not identify any studies that specifically addressed the performance of DCTs in distinct settings, such as Indigenous or rural communities. This highlights a need for more inclusive and context-sensitive studies that reflect the unregulated drug market in various locations. Notably, this review did not capture the perspectives of PWUD because qualitative or participatory research was beyond its scope, representing an important avenue for future inquiry.

The current review aligns with the research and recommendations about the strengths of confirmatory lab testing and the limitations of rapid, point-of-care devices for detecting complex drug mixtures.^{37,51} Differences in findings, such as the improved sensitivity of newer portable GC-MS devices, likely reflect technological advancements and the expansion of spectral libraries since earlier studies.⁴⁵ In addition, while evidence for some technologies is well established, other new and emerging DCTs remain in early stages of evaluation. These gaps emphasize the importance of ongoing research and validation efforts.

Considerations for Future Research

Future research on DCTs should focus on improving both methodological rigour and real-world applicability. Comparative studies using standardized protocols and confirmatory lab testing (e.g., LC-MS-MS or GC-MS) are needed to accurately assess the sensitivity, specificity, and LOD of various technologies across

different drug types, matrices, and concentrations. Larger multisite studies that capture the diversity of unregulated drug markets would help improve the generalizability of findings. Research should also explore the performance of multimethod approaches, such as pairing FTIR spectroscopy with ITS or confirmatory lab testing, to overcome the limitations of single devices. Additionally, studies should evaluate the cost-effectiveness, scalability, and operational feasibility of DCTs in community settings. Finally, research must address the detection of emerging synthetic analogues and contaminants, which requires the continuous updating of spectral libraries, reagent tests, and device capabilities to keep pace with rapidly evolving drug supplies.

Emerging Technologies

This report included peer-reviewed studies plus costing information provided by manufacturers who responded to our query. A key limitation of the existing literature is its heavy emphasis on ITS and FTIR testing, reflecting the early adoption and availability of these methods rather than the full spectrum of new and emerging technologies. Although these approaches are well studied, they present analytical limitations, particularly for multicomponent or untargeted analyses. MS-based systems, which offer higher sensitivity and broader detection capabilities, are comparatively less represented in the current literature. Overall, the research landscape has been shaped by early adopted DCTs, with more recent advancements, including Canadian contributions, yet to gain comparable visibility or integration into mainstream DCT studies. Our review of grey literature and other resources highlights several of the emerging DCTs that have been developed and are being piloted in Canada and internationally and that have not yet been fully validated or widely published in the scientific literature.²⁹ These innovations often aim to address limitations of existing methods by improving portability, speed, sensitivity, or ease of use. Two of these new technologies, SERS⁴¹ and portable GC-MS,⁴² were evaluated in the included studies of this review. Other notable emerging technologies include ion mobility spectrometry,⁶² Scatr's Series One,⁶³ Spectra Plasmonics Amplifi IDTM,²⁹ and Waters' Radian ASAP,⁶⁴ portable robotic high performance liquid chromatography,²⁹ portable near-infrared technology,⁶⁵ miniature MS,^{66,67} portable PS-MS,^{68,69} DoseCheck technologies (voltammetry and electrochemical analysis),²⁹ and mobile-IR.²⁹

All these technologies share the common goal of enabling rapid, onsite chemical analysis of substances outside traditional laboratory settings.²⁹ They are designed to provide timely and actionable information about the composition of substances, often at trace levels and with minimal sample preparation. Whether based on spectroscopy (e.g., near-infrared, Raman, and SERS) or mass spectrometry (e.g., ion mobility spectrometry, miniature MS, PS-MS, and Radian ASAP), each technology relies on comparison with spectral or mass reference libraries to identify unknown or mixed substances. Their portability and increasingly user-friendly interfaces suggest potential suitability for use in community or clinical settings. A key aim for these emerging technologies is to balance trade-offs between sensitivity, specificity, cost, and ease of use. Importantly, these tools are increasingly being piloted in harm reduction settings in Canada and internationally, where they can detect contaminants in unregulated drug supplies and provide both individual-level feedback and population-level early warning data. There is little evidence of formal evaluation for most of these new instruments. Most are in the research, development, and evaluation stages, and some are in the field-testing stage.²⁹

Given the rapidly evolving landscape of DCTs, ongoing research, validation, and pilot implementation studies are warranted to determine their accuracy, effectiveness, and practical suitability for various harm reduction settings. While laboratory testing is essential, field testing is particularly important, as it evaluates technologies in real-world contexts, such as in community-based drug-checking programs or at music festivals using samples from the unregulated drug supply.²⁹ For example, Toronto's DCS and Ontario's Drug Checking Community leads performance assessments of various DCTs available for sale in Canada using unregulated substance samples collected throughout Ontario and gold standard mass spectrometry instrumentation.⁷⁰ The British Columbia Centre on Substance Use collaborates with service delivery partners, laboratory services such as Health Canada's Drug Analysis Service),⁷¹ and manufacturers to conduct field-testing pilots and verify the performance of new and emerging DCTs when used in real-world settings in Ontario⁷⁰ and British Columbia.²⁹ In recent years, drug-checking sites across Canada have been collaborating with their partners and Health Canada to field test a number of emerging technologies and develop recommendations for their use in their respective jurisdictions.⁷¹ Although many of the field-test results have not yet been published in academic outlets, they draw on community-generated knowledge and structured pilot studies, highlighting the importance of both conducting field-based evaluations and sharing findings to inform broader adoption of various DCTs and best practices.²⁹

Considerations for Substance Use Services and Support and Policy-Making

When implementing DCTs in clinical or community settings, decision-makers must balance analytical accuracy with operational feasibility. No single technology can detect the full range of substances in today's rapidly evolving drug market, particularly low-concentration compounds or emerging synthetic analogues, such as carfentanil or novel fentanyl derivatives.^{41,51} Consequently, multimethod approaches, combining point-of-care devices like FTIR spectroscopy and ITS (e.g., BTS) with confirmatory lab testing (e.g., GC-MS or LC-MS-MS), are often required to ensure accuracy of detection.^{41,51} This layered strategy allows front-line services to provide quick, actionable information while still having access to confirmatory lab testing for complex or ambiguous samples. However, 2 included studies^{36,43} have evaluated this approach.

Cost-effectiveness and sustainability are also central considerations. High-performance technologies, like portable GC-MS, can provide detailed and accurate results but come with high costs, significant maintenance requirements, and the need for specialized technical expertise.^{42,45} In contrast, low-cost tools, such as ITS or colorimetric reagents, may be more feasible for widespread implementation but have narrower detection capabilities and may miss critical contaminants or analogues. Policy-makers must assess resource allocation, including training needs, infrastructure requirements, and supply chains, to ensure that DCSs remain reliable and scalable over time.

Drug-checking data and services are an important component of the public health response to the toxic drug crisis.^{16,27} Much of what we now know about the variability in the drug supply comes from the data made available through these services.^{27,71} Investment in research, cross-jurisdictional data sharing, and partnerships between harm reduction services and laboratories can help ensure that DCTs remain responsive and evidence-informed. However, existing legislative requirements, such as permits and exemptions for handling, transporting, storing, and testing controlled substances, can vary by jurisdiction

and setting, and they may influence the feasibility of such studies. Acknowledging these regulatory contexts is important while planning and advancing research and implementation efforts. Policy-makers may also consider how data from DCSs can be integrated into public health surveillance systems to monitor trends, enhance community awareness of toxic and highly potent drugs, and inform proactive interventions.⁴⁴

Implications for First Nations, Inuit, and Métis Peoples

In Canada, First Nations, Inuit, and Métis Peoples experience higher rates of unregulated substance use and experience a disproportionate burden of the harms associated with unregulated substance use as compared to non-Indigenous people due to documented barriers, including racism, discrimination, and marginalization within health care systems in Canada.⁷² Drug checking as a harm reduction approach remains underexplored from Indigenous, decolonial, and culturally centred perspectives.⁷³ This includes considerations of data sovereignty and the value of such data for First Nations, Inuit, and Métis Peoples to monitor and respond to the unregulated drug supply. One recent publication offers guiding principles and foundational insights to (re)conceptualize drug checking in alignment with First Nations, Inuit, and Métis cultural values, ancestral knowledge, and community-based knowledge and worldviews that emphasize wellness, healing, and (re) connection.⁷³ Additionally, Tla'amin First Nation's community-based, Indigenous-led harm reduction program, ʔaḵimət, incorporates the Tla'amin First Nation's language, culture, and ways of being into all aspects of its programming related to the use of unregulated drugs, including its DCSs.²² As of 2023, it was the only community-owned and Indigenous-led harm reduction intervention in Canada and could provide a basis for other Indigenous communities to draw upon when developing similar interventions in their communities.

Ethics and Equity Considerations

Reducing Harms and Informed Consent

The overarching ethical aim of harm reduction interventions, including DCSs, is to reduce the negative consequences of certain activities.⁷⁴ In connection with the use of DCTs, this means DCTs should provide highly accurate findings — that is, findings should provide comprehensive results in terms of detecting contaminants and have low FN rates. Research has shown that the accuracy of DCT test results is a concern for PWUD who access DCSs.³¹ Our findings identified that the DCTs reviewed for this report had variable accuracy and LOD, which may have implications for the potential of these DCTs to achieve the overall goal of harm reduction.

The findings in this report also have implications for informed consent. To respect human autonomy, people have the right to be informed of the potential risks and benefits of interventions.⁷⁵

The communication of results must be accurate, transparent, and tailored to ensure PWUD can make informed decisions about their substance use.⁴³ The risk of FN or incomplete results (e.g., when certain contaminants or analogues are undetectable by a given technology) must be clearly communicated to prevent harm or a false sense of safety.^{39,43}

Access to DCSs

In the context of Canada, recent research has highlighted that PWUD consider lack of access to be a major barrier to using DCTs and DCSs.⁷⁶ Access to DCSs is often uneven, with rural, remote, and underserved communities, which are disproportionately impacted by the toxic drug supply, facing significant barriers. These include limited availability of equipment, lack of trained personnel, and logistical challenges in transporting samples for confirmatory lab testing. Collectively, this differential access to DCSs likely contributes to health inequities, given that some populations of PWUD will bear a disproportionate risk of adverse health outcomes because of disparities in access to DCSs. This highlights the need for technologies that can support broader access, particularly across geographical regions. Ensuring equitable access requires investment in mobile or decentralized testing services as well as culturally safe and stigma-free environments that encourage PWUD seek these services without fear of criminalization or discrimination.

Ethical implementation also requires considering the affordability and sustainability of DCTs so that communities are not left without essential services due to resource constraints. This includes ensuring that PWUD living in rural and/or remote communities have the same access to advanced DCTs with high accuracy as urban or better-funded regions. Collaboration with PWUD, community-based organizations, and First Nations, Inuit, and Métis communities is essential for designing services that are equitable, respectful of lived experiences, and aligned with culturally informed and harm reduction principles.

Privacy

Privacy refers to the right of individuals to be free from intrusion or interference by others.⁷⁷ Individuals have privacy interests “in relation to their bodies, personal information, expressed thoughts and opinions, personal communications with others, and the spaces they occupy.”⁷⁷ In the context of Canada, ensuring privacy requires abiding by the relevant provincial or territorial data privacy laws and regulations (e.g., Ontario’s *Personal Health Information Protection Act*, Nova Scotia’s and British Columbia’s *Freedom of Information and Protection of Privacy Acts*). Additional privacy considerations are articulated in First Nations, Inuit, and Métis data sovereignty principles — including the First Nations principles of OCAP (ownership, control, access, and possession), Manitoba Métis principles of OCAS (ownership, control, access, and stewardship), Inuit Qaujimajatuqangit, and the Engagement, Governance, Access and Protection (EGAP) Framework that guides the collection, storage, and use of race-based data from Black communities.⁷⁸ The use of DCTs and DCSs can give rise to data privacy considerations and physical privacy considerations associated with accessing DCS receiving results.

In some jurisdictions, the use of DCSs may require the collection of personal information to inform individuals of the contents of their drug supply.²² Additionally, this information is often aggregated and used for broader purposes, including identifying trends and informing program and policy decisions.²² The use of cloud servers with subscription-based access may pose additional challenges, particularly when negotiating data agreements with regional health authorities and community partners, and in relation to the potential commercial use of these data. Consent conversations with people accessing DCSs should include information on the steps that will be taken to ensure that users’ personal information is collected, stored, used, transmitted, and disposed of according to the relevant provincial privacy standards and other guiding

frameworks and principles when relevant. Additionally, programs must balance individual privacy with public health surveillance, ensuring that data collected from DCSs is anonymized and used in ways that benefit communities rather than perpetuate stigma or punitive responses.

The use of DCSs and DCTs also requires safeguarding people's physical privacy in connection with accessing DCSs. Recent research has highlighted that PWUD are concerned about being identified as a person who uses unregulated drugs due to accessing DCSs.⁷⁹ These concerns may be mitigated if DCSs are based in locations offering multiple services;⁷⁹ however, it also may be more challenging to protect people's physical privacy in these contexts.⁸⁰ People may also prefer to receive the results of their tests in an individualized manner rather than having to access their results through a website or other public channel.⁸¹ For example, British Columbia has expanded its client results portal to allow people to access their own results anonymously and privately.⁸²⁻⁸⁴

Legal Considerations

In addition to the importance of adherence to relevant privacy legislation, legal risks have been identified as among the most common barriers to accessing DCSs by PWUD.³¹ In the context of Canada, PWUD have expressed concern about the potential that possessing illegal drugs and/or drug testing equipment could lead to criminal charges.⁸⁵ To reduce the risk of criminalization and support the use of DCSs, some Canadian jurisdictions have applied for and have been granted legal exemption from Canada's *Controlled Drugs and Substance Act* to decriminalize the possession of small amounts of unregulated drugs for personal use (e.g., the province of British Columbia), and other jurisdictions have applied for this exemption (e.g., the City of Toronto). Establishing supportive relationships between law enforcement bodies and DCSs has been suggested as an additional means to reduce the fear of criminalization and, therefore, to facilitate the use of DCSs by PWUD.⁸⁵

Conclusion

This review underscores both the strengths and limitations of current DCTs. While point-of-care approaches show variable accuracy, particularly for complex or low-concentration substances, confirmatory laboratory-based DCTs demonstrate high sensitivity. In Canada, provinces like Ontario and British Columbia have piloted and expanded community drug-checking programs that integrate several of these technologies,^{36,37,41,43,47,49,50,53} often combining ITS and portable IR, FTIR, and Raman spectrometers at the point of care while sending complex or inconclusive samples to centralized laboratories equipped with highly sensitive and specific devices. Evidence gaps — especially regarding multimethod approaches, cost-effectiveness, diverse settings, and user perspectives — limit current conclusions. Continued research and validation are needed to ensure these technologies are accurate, feasible, and contextually relevant.

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Appendix 1: Detailed Methods and Selection of Included Studies

Please note that this appendix has not been copy-edited.

Canada's Drug Agency (CDA-AMC) received an external request on the topic of DCTs. Based on this request, an informal scoping exercise, including searching and screening evidence from preliminary literature searches, was conducted to identify key priorities for an evidence review on DCTs about their various considerations (e.g., accuracy, LOD, costs). We also developed a questionnaire to gather expert input from the NDCWG on specific areas that informed the content of this report. Based on the results of this scoping exercise and experts' feedback, and balancing rigour and feasibility considerations, we developed a prespecified project plan and conducted a customized health technology review to address the research questions, specifically a rapid review of primary studies according to Cochrane standards.⁸⁶ Ethics and equity considerations were integrated throughout the report using prespecified analytic categories developed by an internal advisor with ethics expertise.

We made adaptations to the project plan, as necessary, to ensure that we addressed the needs of the request while maintaining methodological rigour and considering the quality of the available evidence. The comparative evidence (i.e., studies including more than 1 index test [i.e., DCT] assessed versus a reference standard [i.e., confirmatory lab testing]) was weak, as all comparisons were made only narratively within the included studies. No comparative accuracy statistics were directly reported. Given the rapid nature of the review, it was not feasible to perform new statistical comparisons of the tests. Therefore, we adopted a noncomparative question which allowed us to include studies that assessed the accuracy of a single index test (i.e., there was not a requirement for a comparator). We did not make formal comparisons within this review and did not appraise the risk of bias in the comparisons made within the included studies. Therefore, readers are cautioned that within-study comparisons may be biased, and between-study comparisons are at high risk of bias due to probable confounding.

To better reflect the realities of drug-checking implementation and practice, we also made several adaptations in how we described the included test accuracy studies on DCTs. Although we selected and appraised the included studies based on the methods used in test accuracy research (e.g., distinguishing index tests and reference standards), we presented the results in language that aligns with the drug-checking practice (e.g., point-of-care and confirmatory lab testing). Drug-checking studies often combine point-of-care and confirmatory lab testing as complementary strategies, rather than as distinct methods, that is, all testing procedures are part of a single approach rather than separate measures. For consistency with this context, we used the term "index test/Intervention" in place of "index test" to reflect that, in the context of drug checking, the testing process itself is not only a diagnostic activity but also constitutes a service that is implemented as part of harm reduction practice. In this sense, "intervention" meant the operational role of drug checking, not an evaluation of its effectiveness. By using the term "index test/Intervention," we acknowledged that the DCTs reviewed were both 'tests' and, at the same time, 'interventions' in service delivery. When reporting the results, we described where and how drug checking was conducted (i.e., at point of care, in laboratory facilities, or both), rather than categorizing the methods as index tests versus

reference standards. This allowed us to represent testing locations and approaches in a way that is more consistent with how drug checking is implemented and evaluated in the real world. We also replaced the term “patient” with “substance sample” throughout the report and appraisal tools. This adaptation was made to better reflect the context of drug-checking studies, where the unit of analysis is the substance sample rather than the patient.

What Is a Rapid Review?

Rapid reviews are based on accelerated and abbreviated systematic review methods, balancing timeliness with rigour, to allow for timely decision-making. Due to these abbreviated methods, rapid reviews have some limitations. For example, unlike in systematic reviews, for which at least 2 independent reviewers are needed to screen studies to reduce selection bias, we followed a liberal-accelerated approach.¹ In this approach, selection by a single reviewer was required to include a study, and exclusion by 2 reviewers was needed to exclude a study.⁸⁷ Similarly, no calculations were done to homogenize the effect measures. Though we used data from within the studies to calculate sensitivity, specificity, and FP and FN rates, we did not calculate confidence intervals due to time constraints inherent in the rapid review process. As a result, the degree of uncertainty around the estimates is not quantified, and readers should interpret the findings with appropriate caution.

National Drug Checking Working Group Survey

We conducted a survey with 8 targeted questions, distributed to members of the NDCWG, to gather expert input on priority areas for our upcoming review of DCTs. The goal was to better understand which technologies and issues—such as accuracy, LOD, costs, and ethical implications—should be central to the review. We received responses from 14 individuals, including front-line workers, harm reduction/psychosocial workers, lab technicians, researchers, project managers, and individuals with lived or living experience. They represented a range of organizations across Canada.

Respondents emphasized the importance of reviewing both emerging technologies and validated ones, with a particular focus on their ability to detect high-priority substances like opioids (most frequently ranked first), benzodiazepines, and stimulants. Contaminants of concern included fentanyl analogues and nitazenes (ultra-high-potency, synthetic opioids). The most important criteria for evaluating technologies were LOD, ease of use, time to result, sensitivity, specificity, and portability. Most participants preferred a review of comparing DCTs against each other, rather than comparing them to clinical testing methods (e.g., urine sample). They also underscored the need to address key ethical considerations, such as unintended consequences (e.g., FNs), accountability and liability, data privacy, and unequal access to services. Additional feedback emphasized the need to include practical factors, such as upfront and ongoing costs, staff training requirements, manufacturer support, and sample-destroying limitations that may impact service delivery.

We shared and discussed the survey results with the internal CDA-AMC team. The findings helped guide our approach to this customized health technology review.

Literature Search Methods

Published literature was identified by searching the following bibliographic databases: MEDLINE and Embase via Ovid. Ovid searches were run simultaneously as a multifile search, retrieval was not limited by publication date, and was limited to the English language. Duplicates were removed using Ovid deduplication for multifile searches, followed by manual deduplication in EndNote. The search strategy comprised both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. Search concepts were developed based on the elements of the PICOS (population, intervention, comparison, outcomes, and study) framework and research questions.

To address research questions 1 and 2, the search was completed in 2 sections on May 26, 2025. The first section was focused on the concept of drug checking, with no filters applied to limit the retrieval by study type. To supplement this search, the second section was completed wherein the main concepts were DCTs and drug contaminants, and filters were applied to this search to limit retrieval to randomized controlled trials, controlled clinical trials, or any other type of clinical trial.

To address research question 3, a filter was applied to the same search concepts as just described to limit retrieval to health economic literature on May 30, 2025. The full search strategy is available upon request.

Selection Criteria and Methods

The literature review management software DistillerSR (Evidence Partners, Ottawa, Ontario) was used to facilitate screening and study selection. In the first level of screening, a pilot round for reviewing abstracts was not conducted; rather, 3 reviewers screened the titles and abstracts retrieved from the literature searches: 1 reviewer with content expertise independently screened all the titles and abstracts retrieved from the literature searches; the 2 other reviewers each screened half of the retrieved titles and abstracts. We followed a liberal-accelerated approach,^{87,88} in which selection by a single reviewer was required to include a study, and exclusion by both reviewers (i.e., reviewer with content expertise and 1 of the other 2 reviewers) was needed to exclude a study.

Full texts of titles and abstracts that were judged to be potentially relevant were retrieved. Following Cochrane rapid review methods guidance,⁸⁶ 2 reviewers independently assessed 20% of the full texts for inclusion using a standard full-text screening form based on the selection criteria outlined in [Table 1](#). They then met to discuss the discrepancies and calibrate the form. Reviewers then split the remaining full texts and each reviewed half of them. If fewer than 5 potentially relevant full texts were identified to address a specific research question, all retrieved full texts were independently assessed by both reviewers. A list of studies excluded after full-text review was provided, along with the reasons for their exclusion. A third reviewer with content expertise reviewed all excluded full texts.

Eligible studies from all countries were included. The final selection of full-text articles was based on the inclusion criteria presented in [Table 1](#).

Exclusion Criteria

Articles were excluded if they:

- did not meet the selection criteria outlined in [Table 1](#),
- were duplicate publications,
- were of any design published only as abstracts, conference proceedings, presentations, thesis documents, or preprints,
- were health technology assessments, systematic reviews, meta-analyses, case studies, and case reports,
- were published in languages other than English (for feasibility reasons),
- compared different manufacturers of the same DCT,
- included drug checking that was not completed by the research team or trained staff (e.g., PWUD, take-home tests).

Inquiring Information From DCT Manufacturers

Based on the initial scoping exercise, we did not anticipate comprehensive information about the costs associated with DCTs from the published literature. In addition to the targeted literature search for costing estimates related to question 4, the DCT manufacturers within and outside of Canada were identified via search engines, by reviewing DCT literature, and through discussions with DCT experts. DCT manufacturers were contacted via email or manufacturer websites to obtain relevant Canadian costing estimates.

Working with our internal expert in health economics, we developed a list of questions regarding costing information and capabilities (e.g., portability, time to result) of DCTs to obtain relevant information from the manufacturers. This included 9 major categories and a total of 43 items with structured questions in the English language. Surveys for DCT manufacturers were contacted via email. Video calls with manufacturers were optional depending on their preferences. A pilot test of the instrument was conducted with the first 5 manufacturers; an email with clear instructions was drafted; and 3 follow-up reminders were sent to increase the response rate. Results were reviewed and summarized by 2 reviewers. Surveys were conducted from June 6, 2025 to August 11, 2025 via email.

Critical Appraisal of Individual Studies

The risk of bias and applicability of the included studies for research question 1 were evaluated using the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) checklist³⁴ for test accuracy studies, for each index test within an included study. Published guidance for this tool was followed. The included studies about outcomes specific to research question 2 were not appraised using a specific tool, because no tool was identified that facilitates a comprehensive appraisal of the relevant outcome measures. The appraisal of studies related to research question 4 was guided by the relevant domains of the Drummond checklist³⁵ and by an assessment of the study methodology (i.e., validity of the assumptions, strength of the data), the overall robustness of the findings (e.g., sufficient sensitivity analyses to adequately inform the

uncertainty and key drivers of results), and the generalizability of these studies to the Canada's health care system (e.g., relevancy of cost information from countries other than Canada, including different health care models of care).

Two reviewers independently piloted the appraisals across at least 1 study and met to resolve any disagreements, to ensure a mutual understanding of the tool. After piloting, 1 reviewer completed the appraisals for the remaining studies. The second reviewer verified all judgments and justifications. Any disagreements were resolved through discussion, with the involvement of a third reviewer if consensus could not be reached.

Summary scores were not calculated for the included studies rather, the strengths and limitations (risk of bias and applicability for accuracy studies) of each included study were described narratively. Specifically, tables were developed to present the answers to the items within the appraisal tools. Studies were not excluded from this review based on the critical appraisal results.

Data Extraction

The data were extracted directly into tables created in Microsoft Word, which was developed and modified, as necessary. Piloting of data extraction tables was performed to ensure only the most important data fields for addressing the research questions were included. In the pilot round, 2 reviewers independently extracted data from 3 included studies, then met to resolve disagreements through discussion until they were satisfied with the content and usability of the tables. Formal data extraction was then performed by 1 reviewer, and a second reviewer independently verified the most important data items (i.e., outcome data, characteristics of the included studies) for accuracy and completeness. Both reviewers independently extracted the data from the full text of 1 study⁵² addressing question 4 and later compared them. Disagreements were resolved through discussion until consensus was reached or through adjudication by a third reviewer, if required.

Relevant information that was extracted included study characteristics, methodology (e.g., study design), index test(s) or intervention, comparator, reference standard (i.e., confirmatory lab testing), and results regarding the outcomes of interest. Where available, the characteristics of the samples used for comparison of DCTs (e.g., brought in by PWUD, submitted by police departments from their unregulated drug samples) were provided. When data were available, certain populations and settings of interest were presented, as defined by study authors and reported in tables in [Appendix 3](#).

Per our project plan, if relevant data conflicted in the included studies (e.g., discrepancies between values reported in the abstract and the main text of a study), we reported all values and described the inconsistency. Due to the project's timeline, no attempts to contact the corresponding authors of included studies were made to obtain missing information or to clarify conflicting information. We did not extract data presented only as figures or graphs that would require manual estimation or extraction using image processing software.

Data Analysis and Synthesis

Detailed descriptions of study characteristics from eligible studies were provided in tables, together with a narrative summary in the main text for an overview. The study and sample characteristics (when the information was available) were considered in the synthesis of the accuracy, LOD, repeatability, reproducibility, cost-effectiveness, and costs within and across the studies, and to identify relevant ethics and equity considerations (e.g., legal considerations, FP/FN rates). When the required data were provided in the studies, we conducted calculations of sensitivity and specificity, as follows, for studies that did not explicitly report them:

- Sensitivity = TP / all positives on the reference standard (i.e., confirmatory lab testing or TP + FN)
- Specificity = TN / all negatives on the reference standard (i.e., confirmatory lab testing or TN + FP)
- FN rate = 1 – Sensitivity or FN / all positives on the reference standard (i.e., confirmatory lab testing or TP + FN)
- FP rate: 1 – Specificity or FP / all negatives on the reference standard (i.e., confirmatory lab testing or TN + FP)

We used the term FN and FP ‘rates’ throughout the review to remain consistent with the terminology used in the included studies, although according to Cochrane guidance, these should more accurately be described as FN and FP “fractions.”¹

A narrative synthesis was conducted as per existing guidance by Popay et al.,⁴¹ with recognition that some adaptation was required due to the nature of the review questions within the context of drug-checking practices. For research question 1, for example, we first grouped studies similar in their population (i.e., substance sample type), intervention or index test, reference standard (i.e., confirmatory lab testing), and outcomes (e.g., accuracy). Next, we developed a preliminary synthesis by organizing the results and identifying patterns in the results. We evaluated within- and between-study relationships and discussed our findings about any differences observed. Outcomes were reported as reported by the study authors.

We planned to assess the overall certainty of the evidence for question 1 using the methods of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.⁸⁹⁻⁹² However, due to heterogeneity in the methods and reporting of the results of included studies, lack of data needed for this assessment, and time constraints of conducting a rapid review (e.g., contacting authors of the included studies to request additional data), it was not feasible to conduct a certainty of evidence appraisal.

Ethics and Equity Considerations

An identification of ethics and equity considerations relevant to the context of DCTs was informed by the EUnetHTA Core Model 3.0 Ethics Domain,⁹³ ethical considerations identified through the survey conducted with members of the NDCWG (e.g., privacy and confidentiality, unintended consequences [e.g., FNs], inequities in access), and by additional harm reduction and ethics literature identified through handsearching. A reviewer with ethics expertise developed prompts and sensitizing concepts to identify and reflect on ethics

and equity considerations associated with the use of DCTs. Responses to these prompts, findings from the targeted literature search, and ethical implications of the results of this review were synthesized to identify relevant ethics and equity implications for PWUD and DCTs. A reviewer with ethics expertise assisted with developing analytic categories to represent the key ethical and equity considerations arising from the identified evidence and with developing the content associated with the ethical considerations associated with the use of DCTs.

Reporting of Findings

This Rapid Review was prepared in consideration of relevant reporting guidelines (i.e., the PRISMA 2020,⁵⁴ and PRISMA-DTA statements).⁹⁴

External Review

Peer Review

Before the review phase began, 1 content expert with expertise in Canada's DCS reviewed the project plan. The final report was externally reviewed by 2 content experts: the same content expert as the project plan and a content expert with expertise in DCTs.

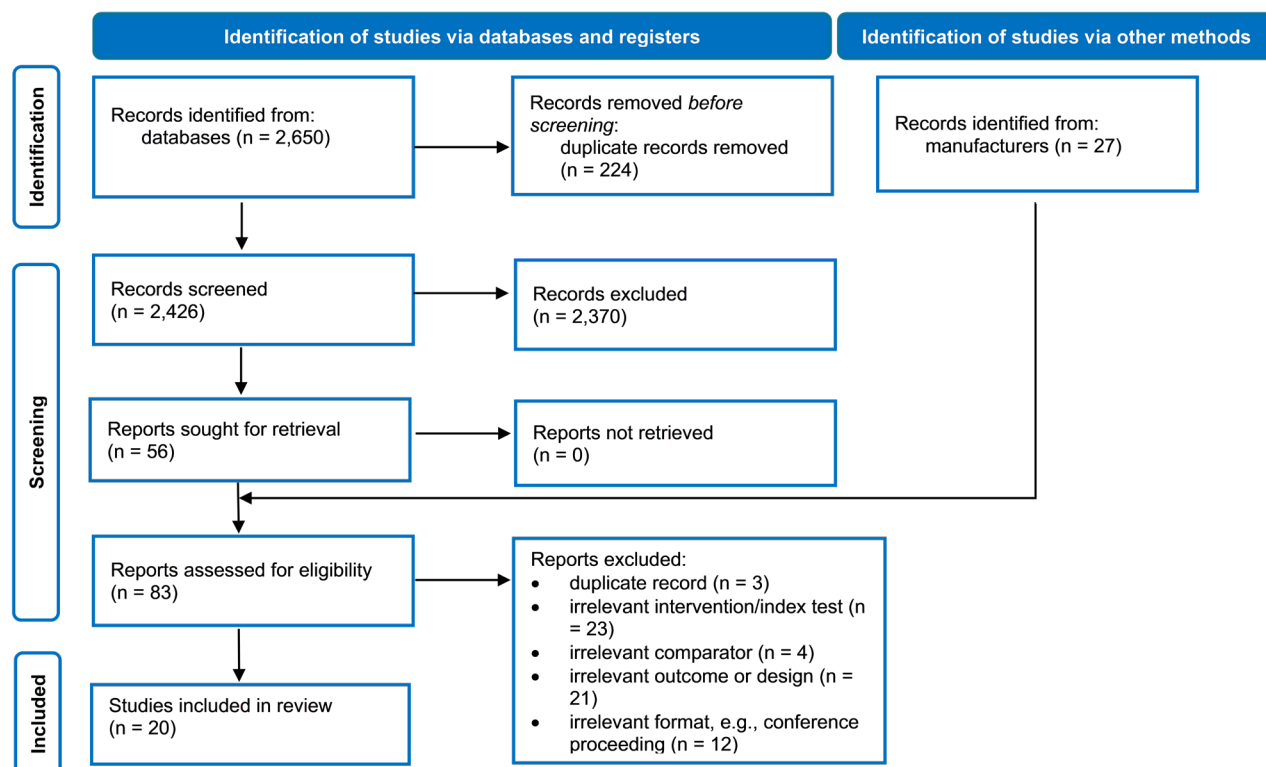
Feedback Opportunity

This draft version of the report was posted on the CDA-AMC website to allow interested parties the opportunity to provide feedback on the draft report. We considered all feedback and revised the report accordingly. Therefore, this final version of the report, reflects the comments and suggestions from peer reviewers and from the feedback opportunity.

Appendix 2: Selection of Included Studies

Please note that this appendix has not been copy-edited.

Figure 1: Selection of Included Studies — PRISMA Flow Chart⁵⁴ of Selected Reports



PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

List of Included Studies

The citations provided in this list are the studies that were included in this customized health technology review (in reverse chronological and alphabetical order).

- Crepeault H, Tobias S, Angelucci J, et al. Detection of benzodiazepines in the unregulated drug supply using point of care and confirmatory drug checking technologies: A validation study. Validation Study. *Drug & Alcohol Dependence*. Jun 01 2025;271:112631. [doi:10.1016/j.drugalcdep.2025.112631](https://doi.org/10.1016/j.drugalcdep.2025.112631) PubMed
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- Park JN, Serafini R, Ujeneza M, et al. Xylazine awareness, desire, use and exposure: Preliminary findings from the Rhode Island community-based drug checking cohort study. *Drug Alcohol Depend Rep*. Jun 2024;11:100247. [doi:10.1016/j.dadr.2024.100247](https://doi.org/10.1016/j.dadr.2024.100247) PubMed
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List of Excluded Publications and Reasons for Exclusion

The citations provided in this list are publications that were excluded after full-text review as part of the rapid review (in reverse chronological and alphabetical order).

Duplicate Record (n = 3)

Borden SA, Saatchi A, Vandergrift GW, et al. A new quantitative drug checking technology for harm reduction: pilot study in Vancouver, Canada using paper spray mass spectrometry. 2022;41(2):410-418.

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Appendix 3: Characteristics of Included Publications

Please note that this appendix has not been copy-edited.

Table 5: Characteristics of the Included Test Accuracy Studies

Study citation, country, funding source ^a	Sample characteristics and setting	Index test(s) or intervention(s) and confirmatory lab testing	Reported outcomes
Crepeault et al. (2025) ³⁶ Canada Funding source: NIH-NIDA	Population: 90,725 samples were tested at point of care. 1,922 (2.1%) underwent confirmatory lab testing Target substance(s): benzodiazepine and its analogues in any submitted sample Source of sample(s): drug samples submitted to harm reduction sites in BC from October 2018 to November 2023 Participant(s): NR	Index test(s) or intervention(s) (manufacturer): FTIR (Bruker), BTS (BTNX Inc.) Confirmatory lab testing (manufacturer): For accuracy: qNMR spectroscopy (NR), irMS (NR), and/or LC-MS (NR) For LOD: qNMR spectroscopy (NR)	Accuracy: sensitivity; specificity; PPV; NPV; FN LOD
Crepeault et al. (2023) ³⁷ Canada Funding source: Health Canada's SUAP; Vancouver Foundation; NIH-NIDA	Population: 22,916 samples were tested at point of care. Of these, 1,467 underwent confirmatory lab testing Target substance(s): fentanyl and its analogues in any submitted sample Source of sample(s): Samples submitted to 16 drug-checking sites, mostly in Vancouver, BC from May 2018 to July 2021 Participant(s): NR	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.), FTIR (Bruker) Confirmatory lab testing (manufacturer): qNMR spectroscopy (NR), GC-MS (NR), and/or LC-MS (NR)	Accuracy: sensitivity
Estrada et al. (2025) ³⁸ US Funding source: CDC, US Department of Health and Human Services Prevention	Population: 1,644 samples were checked at point of care. All samples underwent confirmatory lab testing Target substance(s): fentanyl in any submitted sample Source of substance sample(s): drop-off samples by PWUD between November 2021 and December 2023 Participant(s): PWUD receiving services from syringe service programs Race, ethnicity, culture, or language: spoke English or Spanish	Index test(s) or intervention(s) (manufacturer): FTIR (Bruker), FTS (NR) Confirmatory lab testing (manufacturer): GC-MS (Agilent Technologies), LC-QTOF-MS (SCIEX, Shimadzu)	Accuracy: TP; TN; FP

Study citation, country, funding source ^a	Sample characteristics and setting	Index test(s) or intervention(s) and confirmatory lab testing	Reported outcomes
	Age, mean (SD): older than 18 years		
Fregonese et al. (2021) ³⁹ Italy Funding source: NR	Population: 120 samples were tested at point of care. All samples underwent confirmatory lab testing Target substance(s): Any composition of unidentified substances Source of substance sample(s): submitted by night event attendees to a harm reduction setting in 2019 Participant(s): attendees of some night events	Index test(s) or intervention(s) (manufacturer): colorimetric reagent (NR) Confirmatory lab testing (manufacturer): GC-MS (Agilent Technologies)	Accuracy: sensitivity; TP
Goncalves et al. (2021) ⁴⁰ France Funding source: NR	Population: 163 drug samples were tested at point of care. All samples underwent confirmatory lab testing. Target substance(s): Any submitted sample Source of sample(s): Samples submitted by PWUD to harm reduction centres from January 2018 to December 2018 Participant(s): PWUD Place of residence:^b 62.7% living in precarious housing Race, ethnicity, culture, or language: 88.2% French nationality Occupations: 47% without resources or living on illegal resources Gender/sex: 90.2% men Age, mean (SD): 35 years Relationships: 94.1% single; 88.2% without children	Index test(s) or intervention(s) (manufacturer): IR spectroscopy (Bruker) Confirmatory lab testing (manufacturer): UPLC-HRMS (Acquity I class system coupled to a Xevo XS G2 QTOF analyzer)	Accuracy: sensitivity; specificity; PPV; NPV; TP; FN; FP
Gozdzialski et al. (2022) ⁴¹ Canada Funding source: Health Canada's SUAP, with additional support from the Vancouver Foundation	Population: 509 opioid samples were tested at point of care using BTS and other methods (their results NR). All samples were analyzed with PS-MS. Of these, 100 samples that received PS-MS testing were also analyzed with SERS. Target substance(s): Etizolam	Index test (s) or intervention(s) (manufacturer): SERS (Agilent Technologies), BTS (BTNX Inc.) Confirmatory lab testing (manufacturer): PS-MS (Thermo Fisher Scientific)	Accuracy: sensitivity; specificity; TP; TN; FP; FN

Study citation, country, funding source ^a	Sample characteristics and setting	Index test(s) or intervention(s) and confirmatory lab testing	Reported outcomes
	in opioid drug mixtures Source of sample(s): Drug samples submitted to a drug-checking service in Victoria, BC, between November 2020 and July 2021 Participants: NR		
Gozdzialski et al. (2021) ⁴² Canada Funding source: Health Canada's SUAP, with additional support from the Vancouver Foundation	Population: 59 samples were tested at point of care. All samples underwent confirmatory lab testing. Target substance(s): Carfentanil and Etizolam in opioid samples Source of sample(s): Drug samples collected as part of an ongoing drug-checking program in Victoria, BC, from December 2020 to February 2021 Participant(s): NR	Index test(s) or intervention(s) (manufacturer): portable GC-MS (Torion T9), portable FTIR (Agilent Technologies) Confirmatory lab testing (manufacturer): For accuracy and LOD: PS-MS (Thermo Fisher Scientific)	Accuracy: sensitivity LOD
Green et al. (2020) ³⁰ US Funding source: Bloomberg American Health Initiative	Population: 210 samples were tested at police department forensic Lab. All samples underwent confirmatory lab testing. Target substance(s): fentanyl analogues Source of sample(s): Seized street-acquired drug samples obtained by police during arrests between September and October 2017 Participant(s): NR	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.), hand-held Raman spectrometer (Thermo Fisher Scientific), FTIR (Bruker) Confirmatory lab testing (manufacturer): For accuracy: GC-MS (NR) For LOD: Powder fentanyl standards (DEA registered vendors [Lipomed, Inc., Cambridge, Massachusetts; Cerilliant Corporation, Round Rock, Texas])	Accuracy: sensitivity; specificity; FP; FN LOD
Laing et al. (2021) ⁴³ Canada Funding source: Health Canada's SUAP	Population: 159 samples were tested at point of care. All samples underwent confirmatory lab testing. Target substance(s): benzodiazepine, including etizolam, flubromazolam, flualprazolam, and flubromazepam in opioids (primarily fentanyl) samples Source of sample(s): Drug samples submitted to harm reduction drug-checking services	Index test(s) or intervention(s) (manufacturer): FTIR (Bruker), BTS (BTNX, Inc.) Confirmatory lab testing (manufacturer): qNMR spectroscopy (Bruker), GC-MS (Agilent Technologies) LC-MS (NR)	Accuracy: FP; FN

Study citation, country, funding source ^a	Sample characteristics and setting	Index test(s) or intervention(s) and confirmatory lab testing	Reported outcomes
	in Vancouver and Surrey, BC, from October 2018 to January 2020 Participant(s): NR		
McCrae et al. (2020) ⁵³ Canada Funding source: Health Canada's SUAP, and Canada Research Chairs program	Population: 283 samples were tested at point of care. All samples underwent confirmatory lab testing. Target substance(s): fentanyl and its analogues in any submitted sample Source of sample(s): Samples submitted to drug-checking services (supervised consumption sites) in October 2017 Participants: NR	Index test(s) or intervention(s) (manufacturer): FTIR (Bruker), FTS (BTNX Inc.) Confirmatory lab testing (manufacturer): qNMR spectroscopy (Bruker)	LOD
Park et al. (2024) ⁴⁴ US Funding source: NIDA	Population: 125 samples were tested at point of care. All samples underwent confirmatory lab testing. Target substance(s): Xylazine in any drug sample Source of sample(s): Samples submitted by PWUD to 'harm reduction organizations, housing services, and public spaces where overdoses occur' between February and August 2023 Participant(s): 125 PWUD Place of residence: ^b Rhode Island residents; 22.4% currently stably housed Race, ethnicity, culture, or language: 48.8% non-Hispanic white, 9.6% non-Hispanic Black, 24.8% Hispanic or Latino/a, 16.8% other race, spoke and understood English Gender or sex: 42.4% female, 55.2% male, 2.4% gender nonconforming or nonbinary Education: 64% completed high school Age, mean (SD): ≥ 18 years, median age 40 years Other: used an illicit drug in the past 30 days	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.), FTIR (Bruker) Confirmatory lab testing (manufacturer): GC-MS (Agilent Technologies), LC-QTOF-MS (SCIEX)	Accuracy: TP; pairwise concordance

Study citation, country, funding source ^a	Sample characteristics and setting	Index test(s) or intervention(s) and confirmatory lab testing	Reported outcomes
Park et al. (2022) ⁴⁵ US Funding source: NIDA	Population: 343 samples were tested at a clinical chemistry laboratory Target substance(s): fentanyl and analogues in any drug sample Source of sample(s): Illicit drugs obtained from law enforcement Participant(s): NR	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.) Confirmatory lab testing (manufacturer): For accuracy: LC-MS-MS (Thermo Electron Northpoint Parkway) For LOD: laboratory-grade fentanyl and high-priority fentanyl analogues (Cayman Chemical Company), and known blank samples	Accuracy: sensitivity; specificity; FP; FN LOD
Sisco et al. (2024) ⁴⁶ US Funding source: Nothing declared	Population: 100 drug residue samples were tested at a laboratory. Target substance(s): Xylazine in any drug sample Source of sample(s): community-acquired drug paraphernalia residue samples obtained through Maryland Department of Health and the Southern Nevada Health Department. The drug paraphernalia types sampled included syringes, plastic bags, wax bags, and pill bottles. Participant(s): NR	Index test(s) or intervention(s) (manufacturer): XTS (BTNX Inc.) Confirmatory lab testing (manufacturer): For accuracy: DART-MS (NR), GC-MS-MS (NR) For LOD and reproducibility: Pure xylazine (laboratory samples)	Accuracy: sensitivity; specificity LOD; Reproducibility
Thompson et al. (2024) ⁴⁸ US Funding source: NIGMS Center of Biomedical Research Excellence (COBRE) on Opioids and Overdose	Population: 41 drug samples were tested at point of care. All samples underwent confirmatory lab testing at Rhode Island Hospital's toxicology laboratory Target substance(s): Xylazine in any drug samples Source of sample(s): dry drug refuse with visible drug residue submitted by centre clients at a community-based Drug-checking service in Rhode Island from April to May 2023 Participant(s): NR	Index test(s) or intervention(s) (manufacturer): XTS (BTNX Inc.) Confirmatory lab testing (manufacturer): LC-QTOF-MS (SCIEX)	Accuracy: TP; FN
Ti et al. (2021) ⁴⁷ Canada Funding source: Health Canada's SUAP grant	Population: 909 drug samples were tested at point of care. All samples underwent confirmatory lab testing at 1 of the partner laboratories.	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.), FTIR (Bruker) Confirmatory lab testing	Accuracy: TP; FN

Study citation, country, funding source ^a	Sample characteristics and setting	Index test(s) or intervention(s) and confirmatory lab testing	Reported outcomes
	Target substance(s): synthetic cannabinoid contamination in the unregulated drug supply Source of sample(s): samples submitted by PWUD for drug checking in Vancouver and Surrey, BC, between January 2018 and December 2019 Participant(s): NR	(manufacturer): GC-MS (Orbitrap), LC-MS (Orbitrap)	
Ti et al. (2020)²³ Canada Funding source: Health Canada's SUAP grant	Population: 331 samples were tested at point of care. All samples underwent confirmatory lab testing at Health Canada's Drug Analysis Service (DAS) laboratory Target substance(s): fentanyl and its analogues Source of sample(s): substances provided by clients of supervised injection sites and sent for lab testing between October 2017 and 2018 (month: NR) Participant(s): NR	Index test(s) or intervention(s) (manufacturer): FTS (NR), FTIR (NR) Confirmatory lab testing (manufacturer): qNMR spectroscopy (NR), GC-MS (NR)	Accuracy: sensitivity; specificity; PPV; NPV; FN; concordance
Tobias et al. (2021)⁴⁹ Canada Funding source: Health Canada's SUAP grant	Population: 139 samples expected to be Xanax (alprazolam or generic tablets) were tested at point of care. Of these, 20 samples of participant-expected alprazolam underwent confirmatory lab testing at Provincial Toxicology Centre (PTC) or Health Canada's Drug Analysis Service (DAS). Target substance(s): alprazolam (contents of counterfeit alprazolam tablets) Source of sample(s): drug samples submitted to an ongoing drug-checking service in BC between October 2017 and March 2020 Participant(s): NR	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.), BTS (BTNX Inc.), FTIR (Bruker) Confirmatory lab testing (manufacturer): GC-MS (NR), LC-MS (NR), qNMR spectroscopy (NR)	Accuracy: TP
Tobias et al. (2020)⁵⁰ Canada Funding source: Health Canada's SUAP grant	Population: 1,342 samples were tested at point of care in Vancouver, and 372 samples were tested at point of care	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.), FTIR (Bruker) Confirmatory lab testing	Accuracy: TP

Study citation, country, funding source ^a	Sample characteristics and setting	Index test(s) or intervention(s) and confirmatory lab testing	Reported outcomes
	in Surrey, BC. Of these, 83 samples underwent confirmatory lab testing at BC Provincial Toxicology Centre. Target substance(s): xylazine in any drug sample Source of sample(s): samples submitted and tested at 2 SCSs in Vancouver and Surrey between June 1, 2018, and November 30, 2018 Participant(s): NR	(manufacturer): GC-MS (Agilent Technologies)	
Whitehead et al. (2023)⁵¹ US Funding source: National Science Foundation (NSF), University of Illinois Chicago Center for Clinical and Translational Science (CCTS) award	Population: 124 samples were tested with both methods at a laboratory setting in Notre Dame, IN. Target substance(s): 22 illicit drugs and cutting agents Source of sample(s): drug samples collected in Chicago, IL from fall 2021 to early spring 2022 Participant(s): individuals seeking syringe exchange and health care services	Index test(s) or intervention(s) (manufacturer): FTS (BTNX Inc.) Confirmatory lab testing (manufacturer): For accuracy: LC-MS-MS (Agilent Technologies) For LOD: Fentanyl concentrations diluted in water and in the extraction solvent	Accuracy: TP; FP; FN LOD

BC = British Columbia; BTS = benzodiazepine test strips; CDC = Centers for Disease Control and Prevention; DART-MS = direct analysis in real time mass spectrometry; FN = false negative; FP = false positive; FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; GC-MS-MS = gas chromatography–tandem mass spectrometry; IR = infrared spectroscopy; LC-MS = liquid chromatography–mass spectrometry; LC-MS-MS = high-precision liquid chromatography–tandem mass spectrometry; LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; LOD = limit of detection; NIH-NIDA = National Institutes of Health–National Institute on Drug Abuse; NPV = negative predictive value; NR = not reported; PPV = positive predictive value; PS-MS = paper spray mass spectrometry; PWUD = people who use drugs; qNMR = quantitative nuclear magnetic resonance; SCS = supervised consumption site; SD = standard deviation; SERS = surface-enhanced Raman spectroscopy; SUAP = Substance Use and Addictions Program; TN = true negative; TP = true positive; UPLC-HRMS = ultraperformance liquid chromatography–high-resolution mass spectroscopy; XTS = xylazine test strips.

^aAll included studies had cross-sectional design.

^bWhen reporting on sex, gender, race, or ethnicity in this Rapid Review, we retained the language used by the original study authors, and, whenever possible, we referred to these groups based on guidance from the CDA-AMC Style Guide⁹ at the time this Rapid Review was conducted, with an understanding that language is constantly evolving.

Table 6: Characteristics of the Included Cost Description Study

Study citation country, funding source	Type of analysis, time horizon, perspective	Population characteristics	Index test(s) or intervention(s) and confirmatory lab testing	Approach	Source of clinical, cost, and utility data used in analysis	Main assumptions
Cepeda et al. (2023) ⁵² US Funding source: NR	Analysis: Costing analysis Time horizon: The program assessed operated 2 days per week for 2 to 3 hours daily from January 27, 2023, to May 4, 2023 Perspective: Payer (health care payer)	Population: 101 drug samples were tested at point of care. All samples underwent confirmatory lab testing at Rhode Island Hospital Toxicology Laboratory for confirmatory testing. Target substance(s): 22 illicit drugs and cutting agents Source of sample(s): Drug samples submitted by PWUD to a new pilot drug checking service in Rhode Island from January 2023 to May 2023 Participant(s): individuals seeking syringe exchange and health care services	Index test(s) or intervention(s) (manufacturer): FTIR (Bruker), FTS (NR) Confirmatory lab testing (manufacturer): Quadrupole Time- of-Flight Mass Spectrometry (NR)	Ingredients-based microcosting study to estimate total service costs during the implementation period	Source of clinical data: NA Source of cost data: All cost inputs required to conduct drug checking (e.g., financial records, equipment catalogues, expenditure reports) regardless of if they were paid or donated Source of utility data: NA	NR

FTIR = Fourier transform infrared; FTS = fentanyl test strips, NA = not applicable; NR = not reported; PWUD = people who use drugs.

Appendix 4: Critical Appraisal of Included Publications

Please note that this appendix has not been copy-edited.

Table 7: Risk of Bias and Applicability Assessment of Crepeault et al. (2025)³⁶ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random samples enrolled?	No	Voluntary sample submission. No random or consecutive selection.
Was a case-control design avoided?	Yes	Not a case-control design.
Did the study avoid inappropriate exclusions?	Unclear	It is not stated whether some were excluded for logistical or resource-related reasons.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
BTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the confirmatory lab testing?	Yes	Index test or intervention was conducted at point of care before confirmatory testing.
If a threshold was used, was it prespecified?	Yes	BTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Index test or intervention was conducted at point of care before confirmatory testing.
If a threshold was used, was it prespecified?	Yes	FTIR detection threshold was pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.

Domain/question	Judgment	Comments
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing used qNMR spectroscopy, GC-MS, or LC-MS, are considered the most accurate drug-checking technologies.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were sent for confirmatory testing shortly after point-of-care testing, minimizing risk of degradation or change.
Did all samples receive a reference standard?	No	Only 2.1% of samples underwent confirmatory testing.
Did samples receive the same reference standard?	Yes	Different confirmatory lab testings with consistent accuracy used as reference standard methodologies.
Were all samples included in the analysis?	Yes	All samples were analyzed with both index tests or intervention and confirmatory lab testing.
Risk of bias: Could the sample flow have introduced bias?	High	Selective confirmatory testing may affect test accuracy estimates.

BTS = benzodiazepine test strips; FTIR = Fourier transform infrared; GC-MS = gas chromatography–mass spectrometry; LC-MS = liquid chromatography–mass spectrometry; qNMR = quantitative nuclear magnetic resonance; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 8: Risk of Bias and Applicability Assessment of Crepeault et al. (2023)³⁷ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Voluntary, nonrandom sample submission. No random or consecutive selection.
Was a case-control design avoided?	Yes	The study did not employ a case-control design. It was based on real-world data from clients voluntarily submitting drug samples.

Domain/question	Judgment	Comments
Did the study avoid inappropriate exclusions?	Unclear	It is not stated whether some were excluded for logistical or resource-related reasons.
Risk of bias: Could the selection of samples have introduced bias?	High	No random or consecutive sampling, exclusion criteria is unclear.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Point-of-care testing was conducted independently, and results were logged before confirmatory testing.
If a threshold was used, was it prespecified?	Yes	The FTIR detection threshold was 3% to 10%.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
FTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Point-of-care testing was conducted independently, and results were logged before confirmatory testing, reducing interpretation bias.
If a threshold was used, was it prespecified?	Yes	FTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing is considered the most accurate drug-checking and highly accurate for identifying fentanyl analogues and concentrations.
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	The data collected at point of care is linked with the results of confirmatory analyses via a unique sample ID.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		

Domain/question	Judgment	Comments
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were sent for confirmatory testing shortly after point-of-care testing, minimizing risk of degradation or change.
Did all samples receive a reference standard?	No	Only a subset (1,467 out of ~ 23,000 samples) underwent confirmatory testing. The subset may not be representative.
Did samples receive the same reference standard?	Yes	Different confirmatory lab testings with consistent accuracy used as reference standard methodologies.
Were all samples included in the analysis?	Unclear	It is unclear whether there are missing outcome data.
Risk of bias: Could the sample flow have introduced bias?	High	A small portion of samples received confirmatory testing.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or intervention(s) in the study.

Table 9: Risk of Bias and Applicability Assessment of Estrada et al. (2025)³⁸ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Voluntary, nonrandom sample submission from 5 harm reduction sites. No random or consecutive selection.
Was a case-control design avoided?	Yes	The study enrolled real-world participants without a case-control design.
Did the study avoid inappropriate exclusions?	Yes	No exclusion criteria were applied.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Index test or intervention was conducted at point of care before confirmatory testing.
If a threshold was used, was it prespecified?	Unclear	FTIR threshold is unclear.

Domain/question	Judgment	Comments
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	It is unclear if there was a predefined threshold for the index test or intervention.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
FTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Index test or intervention was conducted at point of care before confirmatory testing.
If a threshold was used, was it prespecified?	Unclear	FTS cut-offs were unclear.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	It is unclear if there was a predefined threshold for the index test or intervention.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Both GC-MS and LC-QTOF-MS (confirmatory lab testing) are the reference standard for identifying components.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were sent for confirmatory testing shortly after point-of-care testing, minimizing risk of degradation or change.
Did all samples receive a reference standard?	No	879 out of 1,644 samples were sent for laboratory testing.
Did samples receive the same reference standard?	Yes	GC-MS and LC-QTOF-MS.
Were all samples included in the analysis?	Yes	All samples were included in the analysis.

Domain/question	Judgment	Comments
Risk of bias: Could the sample flow have introduced bias?	High	Selective confirmatory testing may affect test accuracy estimates.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; QA = quality assurance; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 10: Risk of Bias and Applicability Assessment of Fregonese et al. (2021)³⁹ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Samples voluntarily submitted by attendees who presented at 5-night events. No random or consecutive selection.
Was a case-control design avoided?	Yes	The study enrolled real-world participants without a case-control design.
Did the study avoid inappropriate exclusions?	Yes	All samples were included; no exclusion criteria were applied.
Risk of bias: Could the selection of samples have introduced bias?	High	Voluntary, nonrandom sample submission.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Onsite testing was done in real time before GC-MS confirmation.
If a threshold was used, was it prespecified?	Yes	Interpretation followed standard colorimetric reagent charts and an internal protocol.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	Interpretation followed a standardized, blinded process.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard/confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	GC-MS (confirmatory lab testing) is the reference standard for identifying components.

Domain/question	Judgment	Comments
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were sent for confirmatory testing shortly after point-of-care testing, minimizing risk of degradation or change.
Did all samples receive a reference standard?	Yes	All 120 samples were analyzed by GC-MS.
Did samples receive the same reference standard?	Yes	GC-MS was consistently used for all samples.
Were all samples included in the analysis?	Yes	All samples submitted were analyzed and reported.
Risk of bias: Could the sample flow have introduced bias?	Low	All samples followed the same flow and were analyzed.

GC-MS = gas chromatography–mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

Table 11: Risk of Bias and Applicability Assessment of Gonçalves et al. (2021)⁴⁰ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Voluntary sample submission. No random or consecutive selection.
Was a case-control design avoided?	Yes	No control group: all samples were from participants were individuals presenting for drug checking.
Did the study avoid inappropriate exclusions?	Yes	27/163 samples excluded postcollection due to external reasons, not a systemic exclusion.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.

Domain/question	Judgment	Comments
Domain 2: Index test or intervention		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	The index test or intervention was conducted first.
If a threshold was used, was it prespecified?	No	No threshold or prespecification reported for IR spectroscopy.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	High	Lack of predefined thresholds could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	UPLC-HRMS is considered the confirmatory lab testing for drug identification.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were sent for confirmatory testing shortly after point-of-care testing, minimizing risk of degradation or change.
Did all samples receive a reference standard?	Yes	All samples were analyzed by the confirmatory lab testing.
Did samples receive the same reference standard?	Yes	All samples underwent UPLC-HRMS testing.
Were all samples included in the analysis?	Yes	All tested samples were included in the analysis.
Risk of bias: Could the sample flow have introduced bias?	Low	'Yes' for all signalling questions.

IR = infrared; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2; UPLC-HRMS = ultraperformance liquid chromatography–high-resolution mass spectroscopy.

Table 12: Risk of Bias and Applicability Assessment of Gozdziński et al. (2022)⁴¹—QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	A subset of opioid samples (n = 100) was selected from a larger pool (n = 509) based on the presence or absence of etizolam. Not a random or consecutive sampling.
Was a case-control design avoided?	No	The study deliberately selected 50 etizolam-positive and 50 etizolam-negative samples, forming a case-control design.
Did the study avoid inappropriate exclusions?	Yes	All samples with confirmed PS-MS results were considered.
Risk of bias: Could the selection of samples have introduced bias?	High	The case-control design may overestimate test performance.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention		
BTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	No	Index test or intervention results were interpreted with knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	Yes	There was a 300 ng/mL cut-off threshold.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	High	Subjective interpretation could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
SERS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	No	Index test or intervention results were interpreted with knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	No	"The absolute intensity of a characteristic peak for etizolam at frequency 1,491 cm ⁻¹ is used to indicate the presence ("Positive" result) or absence ("Negative" result) of etizolam given a set threshold based on peak intensity. This threshold was determined by simultaneously maximizing true positive and minimizing false negative rates."

Domain/question	Judgment	Comments
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	High	Lack of predefined thresholds and subjective interpretation could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	PS-MS is considered a highly accurate and validated method.
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	PS-MS was performed first.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	All tests were conducted within a reasonable time frame, from November 2020 to July 2021.
Did all samples receive a reference standard?	Yes	All samples received PS-MS testing.
Did samples receive the same reference standard?	Yes	All samples were evaluated using the same PS-MS protocol.
Were all samples included in the analysis?	Yes	All tested samples were analyzed; 2 missing test strip data were excluded.
Risk of bias: Could the sample flow have introduced bias?	Low	'Yes' for all signalling questions.

BTS = benzodiazepine test strips; PS-MS = paper spray–mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2; SERS = surface-enhanced Raman spectroscopy.

Table 13: Risk of Bias and Applicability Assessment of Gozdziński et al. (2021)⁴² — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Voluntary submission. No random or consecutive selection.
Was a case-control design avoided?	Yes	Not a case-control design.
Did the study avoid inappropriate exclusions?	Yes	No exclusions were reported.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	No	Index test or intervention results were interpreted with knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	No	The study did not report a prespecified threshold.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	High	Possible subjective interpretation and lack of predefined thresholds could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Portable GC-MS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	No	Index test or intervention results were interpreted with knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	No	The study did not report a prespecified threshold.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	High	Possible subjective interpretation and lack of predefined thresholds could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		

Domain/question	Judgment	Comments
Is the reference standard likely to correctly classify the target condition?	Yes	PS-MS is a highly sensitive and validated laboratory-based confirmatory technique.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were processed in a short time frame. While the tests were not simultaneous, no degradation or clinical change is expected for solid samples.
Did all samples receive a reference standard?	Yes	All 59 samples received both index and reference tests.
Did samples receive the same reference standard?	Yes	PS-MS was used consistently across all samples.
Were all samples included in the analysis?	Yes	All tested samples were analyzed and reported.
Risk of bias: Could the sample flow have introduced bias?	Low	'Yes' for all signalling questions.

FTIR = Fourier transform infrared; GC-MS = gas chromatography–mass spectrometry; PS-MS = paper spray mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 14: Risk of Bias and Applicability Assessment of Green et al. (2020)³⁰ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	210 seized drug samples (106 fentanyl-positive, 104 fentanyl-negative) were included. Not a consecutive or random sampling.
Was a case-control design avoided?	No	Not a case-control design.
Did the study avoid inappropriate exclusions?	Yes	No samples were excluded inappropriately.
Risk of bias: Could the selection of samples have introduced bias?	High	High risk of bias due to nonrandom sampling and case-control design.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.

Domain/question	Judgment	Comments
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	The index test or intervention results interpreted without knowledge of the results of the confirmatory lab testing.
If a threshold was used, was it prespecified?	Yes	Thresholds (e.g., detection limit) followed manufacturer guidelines or published protocols; no post hoc thresholds were introduced.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
FTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	The index test or intervention results interpreted without knowledge of the results of the confirmatory lab testing.
If a threshold was used, was it prespecified?	Yes	FTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Hand-held Raman spectrometer		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	The index test or intervention results interpreted without knowledge of the results of the confirmatory lab testing.
If a threshold was used, was it prespecified?	Yes	Testing followed established protocols with prespecified thresholds.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing (i.e., GC-MS) is widely accepted as the most accurate drug-checking technology for drug component identification.

Domain/question	Judgment	Comments
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	GC-MS testing preceded and was independent of index testing or intervention.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Testing was conducted within a close time frame at 2 labs (September to October 2017), minimizing degradation or storage-related effects.
Did all samples receive a reference standard?	Yes	All 210 samples had GC-MS results before index testing or intervention.
Did samples receive the same reference standard?	Yes	GC-MS protocols were harmonized across sites.
Were all samples included in the analysis?	Yes	No samples were excluded postenrolment.
Risk of bias: Could the sample flow have introduced bias?	Low	'Yes' for all signalling questions.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 15: Risk of Bias and Applicability Assessment of Laing et al. (2021)⁴³ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Convenience sampling of discarded or unclaimed specimens. No random or consecutive selection.
Was a case-control design avoided?	Yes	Not a case-control design.
Did the study avoid inappropriate exclusions?	Yes	No significant exclusions reported.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
BTS		
A. Risk of bias		

Domain/question	Judgment	Comments
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Point-of-care testing conducted blinded to confirmatory results.
If a threshold was used, was it prespecified?	Yes	Testing followed established protocols with prespecified thresholds.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The index test or intervention is relevant to the real-world harm reduction context.
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Point-of-care testing conducted blinded to confirmatory lab testing results.
If a threshold was used, was it prespecified?	Yes	Testing followed established protocols with prespecified thresholds.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' for all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard or confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing (GC-MS, LC-QTOF-MS, and qNMR spectroscopy) are considered the most accurate drug-checking methods for identifying benzodiazepines.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Unclear	Timeline between tests not clearly reported. May impact accuracy if delays occurred.

Domain/question	Judgment	Comments
Did all samples receive a reference standard?	No	159 out of 1,368 samples received a confirmatory lab testing.
Did samples receive the same reference standard?	No	Some samples tested by the BC Toxicology Centre, others by Health Canada; methods might differ.
Were all samples included in the analysis?	Yes	All tested samples were included in the analysis.
Risk of bias: Could the Sample flow have introduced bias?	High	Due to inconsistent application of confirmatory lab testing.

BTS = benzodiazepine test strips; FTIR = Fourier transform infrared; GC-MS = gas chromatography–mass spectrometry; LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; qNMR = quantitative nuclear magnetic resonance; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 16: Risk of Bias and Applicability Assessment of Park et al. (2024)⁴⁴ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Participants were recruited via outreach and word-of-mouth; not randomized or consecutive selection.
Was a case-control design avoided?	Yes	Not a case-control design.
Did the study avoid inappropriate exclusions?	Yes	All participants meeting inclusion criteria (≥ 18 years old, drug use in past 30 days, and so forth) and providing valid samples were included.
Risk of bias: Could the selection of samples have introduced bias?	High	Voluntary submission of samples introduces a potential selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	FTIR was administered in the field before lab confirmation.
If a threshold was used, was it prespecified?	Yes	Testing procedures were standardized and protocol-driven.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' to all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
FTS		

Domain/question	Judgment	Comments
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	FTS were administered in the field before lab confirmation.
If a threshold was used, was it prespecified?	Yes	FTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' to all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing (GC-MS and LC-QTOF-MS) are the most accurate drug-checking techniques with validated protocols.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were sent promptly from community testing to the lab.
Did all samples receive a reference standard?	Yes	All samples received a confirmatory lab testing.
Did samples receive the same reference standard?	Yes	Uniform testing methods were used across all samples.
Were all samples included in the analysis?	Yes	All samples were analyzed.
Risk of bias: Could the sample flow have introduced bias?	Low	'Yes' to all signalling questions.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 17: Risk of Bias and Applicability Assessment of Park et al. (2022)⁴⁵ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Samples were obtained from law enforcement seizures, not enrolled consecutively or randomly.
Was a case-control design avoided?	Yes	The study was a test accuracy evaluation of seized drug samples, not a case-control design.
Did the study avoid inappropriate exclusions?	Yes	Only samples with untestable or novel analogues (n = 5) were excluded, which was justified.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	FTS testing was conducted independently at the lab before LC-MS-MS reference testing.
If a threshold was used, was it prespecified?	Yes	FTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' to all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing (LC-MS-MS) are the most accurate drug-checking method for substance detection.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.

Domain/question	Judgment	Comments
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Testing occurred under controlled lab conditions with timely procedures.
Did all samples receive a reference standard?	Yes	All 343 samples underwent both FTS and LC-MS-MS testing.
Did samples receive the same reference standard?	Yes	LC-MS-MS was applied consistently to all samples.
Were all samples included in the analysis?	Yes	All samples (except the 5 excluded due to incompatibility with testing) were included.
Risk of bias: Could the sample flow have introduced bias?	Low	Minimal risk as all eligible samples were analyzed consistently.

FTS = fentanyl test strips; LC-MS-MS = high-precision liquid chromatography–tandem mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

Table 18: Risk of Bias and Applicability Assessment of Sisco et al. (2024)⁴⁶ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Drug residue samples from used paraphernalia were voluntarily submitted for analysis.
Was a case-control design avoided?	Yes	The study did not employ a case-control design; it used observational sampling of paraphernalia.
Did the study avoid inappropriate exclusions?	Yes	All collected samples were included; no inappropriate exclusions reported.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	Yes	The threshold (1 mcg/mL) was based on the manufacturer's listed cut-off.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation could introduce bias.
B. Concerns regarding applicability		

Domain/question	Judgment	Comments
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard or confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	GC-MS-MS is a robust and accepted standard for drug identification and quantification.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Both tests were performed on the same sample extracts.
Did all samples receive a reference standard?	Yes	All samples were analyzed using GC-MS-MS.
Did samples receive the same reference standard?	Yes	Uniform testing protocol with GC-MS-MS was followed.
Were all samples included in the analysis?	Yes	All 100 samples were included in the analysis.
Risk of bias: Could the sample flow have introduced bias?	Low	No exclusions or losses reported in sample processing.

GC-MS-MS = gas chromatography–tandem mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2; XTS = xylazine test strips.

Table 19: Risk of Bias and Applicability Assessment of Thompson et al. (2024)⁴⁸ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Samples were submitted voluntarily by clients at a harm reduction drop-in centre, not randomized or consecutive.
Was a case-control design avoided?	Yes	The study did not employ a case-control design.
Did the study avoid inappropriate exclusions?	Yes	All eligible samples (n = 41) were analyzed; ineligible samples (e.g., sharps) were excluded for safety reasons.

Domain/question	Judgment	Comments
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Results were interpreted before the LC-QTOF-MS testing and verified independently by a second team member.
If a threshold was used, was it prespecified?	Yes	XTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Low	'Yes' to all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	LC-QTOF-MS is a sensitive and specific technique widely accepted for drug detection; thresholds (1 ng/mL to 10 ng/mL) were clearly defined.
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	The toxicology lab was blinded to XTS results. All data interpretation was verified by a lab director.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	'Yes' to all signalling questions.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point-of-care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were tested in the field, then sent weekly to the lab. This short interval minimizes degradation.
Did all samples receive a reference standard?	Yes	All 41 residue samples underwent LC-QTOF-MS testing.
Did samples receive the same reference standard?	Yes	The same LC-QTOF-MS protocol and instrumentation were used across all samples.
Were all samples included in the analysis?	Yes	No exclusion was reported; all samples tested were included in analysis.

Domain/question	Judgment	Comments
Risk of bias: Could the sample flow have introduced bias?	Low	'Yes' to all signalling questions.

LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2; XTS = xylazine test strips.

Table 20: Risk of Bias and Applicability Assessment of Ti et al. (2021)⁴⁷ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Samples were submitted by participants on voluntary engagement with harm reduction services, not randomized or consecutive.
Was a case-control design avoided?	Yes	The study did not employ a case-control design.
Did the study avoid inappropriate exclusions?	Yes	All participants meeting eligibility were included without reported exclusions.
Risk of bias: Could the selection of samples have introduced bias?	High	No — random sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory lab testing.
If a threshold was used, was it prespecified?	Unclear	It is unclear if there was a predefined threshold for the index test or intervention.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation and lack of predefined thresholds could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
FTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	Unclear	It is unclear if there was a predefined threshold for the index test or intervention.

Domain/question	Judgment	Comments
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation and lack of predefined thresholds could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing included GC-MS and LC-QTOF-MS, which are the most accurate drug-checking technologies.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Confirmatory tests were conducted shortly after index tests or interventions on the same samples.
Did all samples receive a reference standard?	No	Only 53 out of 318 samples received confirmatory testing.
Did samples receive the same reference standard?	Yes	Confirmatory testing used standard procedures (GC-MS and LC-QTOF-MS) across samples.
Were all samples included in the analysis?	Yes	All tested samples were included in the analysis.
Risk of bias: Could the sample flow have introduced bias?	High	Selective confirmatory testing may bias performance evaluation.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 21: Risk of Bias and Applicability Assessment of Ti et al. (2020)²³ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		

Domain/question	Judgment	Comments
Was a consecutive or random sample enrolled?	No	Convenience samples of submitted drugs were analyzed; no random or consecutive sampling was used.
Was a case-control design avoided?	Yes	It was not a case-control design.
Did the study avoid inappropriate exclusions?	Yes	All eligible samples were included.
Risk of bias: Could the selection of samples have introduced bias?	High	Use of convenience sampling may have introduced selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether the interpretation of FTIR results was conducted independently or with prior knowledge of confirmatory test outcomes.
If a threshold was used, was it prespecified?	Unclear	It is unclear if there was a predefined threshold for the index test or intervention.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation and lack of predefined thresholds could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
FTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether the interpretation of FTS results was conducted independently or with prior knowledge of confirmatory lab testing outcomes.
If a threshold was used, was it prespecified?	Unclear	It is unclear if there was a predefined threshold for the index test or intervention.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation and lack of predefined thresholds could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		

Domain/question	Judgment	Comments
Is the reference standard likely to correctly classify the target condition?	Yes	GC-MS, LC-MS, and qNMR spectroscopy are valid, highly specific reference methods for substance identification.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Samples were analyzed in sequence as part of the drug-checking workflow.
Did all samples receive a reference standard?	No	Only a subset of samples underwent confirmatory laboratory testing.
Did samples receive the same reference standard?	Yes	Confirmatory methods were consistently GC-MS, LC-MS, and/or qNMR spectroscopy.
Were all samples included in the analysis?	Yes	All tested samples were included in the analysis.
Risk of bias: Could the sample flow have introduced bias?	High	Selective confirmatory testing could lead to bias.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; LC-MS = liquid chromatography–mass spectrometry; qNMR = quantitative nuclear magnetic resonance; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

*The appraisal applies to all the index tests or intervention in the study.

Table 22: Risk of Bias and Applicability Assessment of Tobias et al. (2021)⁴⁹ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Sample submission was based on individuals voluntarily accessing drug checking services; not randomized or consecutive.
Was a case-control design avoided?	Yes	Not a case-control study.
Did the study avoid inappropriate exclusions?	Yes	All submitted “alprazolam” tablet samples with FTIR and BTS results were included.
Risk of bias: Could the selection of samples have introduced bias?	High	Voluntary, convenience-based sample submission may introduce selection bias.
B. Concerns regarding applicability		

Domain/question	Judgment	Comments
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
BTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	Yes	FTIR matching procedures were standard and prespecified.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	Yes	BTS cut-off levels were standard and prespecified.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing (GC-MS, LC-MS, and qNMR spectroscopy) are the most accurate drug-checking methods.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		

Domain/question	Judgment	Comments
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Confirmatory testing followed point-of-care analysis without undue delay.
Did all samples receive a reference standard?	No	Only a subset (20/139) of samples underwent confirmatory analysis.
Did samples receive the same reference standard?	Yes	All confirmatory samples were tested using GC-MS.
Were all samples included in the analysis?	Yes	All tested samples were included analysis.
Risk of bias: Could the sample flow have introduced bias?	High	Confirmatory analysis of a subset of samples may not represent full sample population.

BTS = benzodiazepine test strips; FTIR = Fourier transform infrared; GC-MS = gas chromatography–mass spectrometry; LC-MS = liquid chromatography–mass spectrometry; qNMR = quantitative nuclear magnetic resonance; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 23: Risk of Bias and Applicability Assessment of Tobias et al. (2020)⁵⁰ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Samples were submitted voluntarily by clients and confirmatory testing was based on convenience sampling.
Was a case-control design avoided?	Yes	This was not a case-control study.
Did the study avoid inappropriate exclusions?	Yes	No inappropriate exclusions were reported.
Risk of bias: Could the selection of samples have introduced bias?	High	Voluntary, convenience-based sample submission may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect the intended use of the drug-checking service.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory lab testing.
If a threshold was used, was it prespecified?	Yes	FTIR detection thresholds were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation could introduce bias.

Domain/question	Judgment	Comments
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
FTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	Yes	FTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Confirmatory lab testing (GC-MS) is considered the most accurate drug-checking technologies in drug identification.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not clarify whether confirmatory analyses were interpreted without knowledge of point-of-care results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	The confirmatory lab testing results are not likely to be influenced by knowledge of index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Confirmatory lab testing followed point-of-care testing in a timely manner.
Did all samples receive a reference standard?	No	Only 83 out of 1,714 total samples received GC-MS confirmatory testing.
Did samples receive the same reference standard?	Yes	All confirmatory samples were tested using GC-MS at the same lab.
Were all samples included in the analysis?	Yes	All tested samples were included in the analysis.

Domain/question	Judgment	Comments
Risk of bias: Could the sample flow have introduced bias?	High	Confirmatory lab testing was performed on a subset of samples, limiting representativeness.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; PWUD = people who use drugs; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 24: Risk of Bias and Applicability Assessment of Whitehead et al. (2023)⁵¹ — QUADAS-2

Domain/question	Judgment	Comments
Domain 1: Sample selection		
A. Risk of bias		
Was a consecutive or random sample enrolled?	No	Sample submissions were voluntary and based on convenience, not randomized or consecutive.
Was a case-control design avoided?	Yes	The study was observational and not designed as a case-control study.
Did the study avoid inappropriate exclusions?	Yes	No inappropriate exclusions were reported; all submitted samples were included.
Risk of bias: Could the selection of samples have introduced bias?	High	Nonrandom sampling may introduce selection bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the included samples do not match the review question?	Low	The samples reflect real-world point of care drug-checking practices.
Domain 2: Index test or intervention^a		
FTIR		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory analyses.
If a threshold was used, was it prespecified?	Yes	FTIR detection thresholds were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
FTS		
A. Risk of bias		
Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	The study does not clarify whether point-of-care results were interpreted without knowledge of confirmatory analyses.

Domain/question	Judgment	Comments
If a threshold was used, was it prespecified?	Yes	FTS cut-offs were pre-established.
Risk of bias: Could the conduct or interpretation of the index test have introduced bias?	Unclear	Possible subjective interpretation could introduce bias.
B. Concerns regarding applicability		
Applicability: Is there concern that the index test, its conduct, or interpretation differ from the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 3: Reference standard and confirmatory lab testing		
A. Risk of bias		
Is the reference standard likely to correctly classify the target condition?	Yes	Laboratory confirmatory analysis (GC-MS or LC-MS) is considered a valid reference standard.
Were the reference standard results interpreted without knowledge of the results of the index test?	Unclear	The study does not report if laboratory personnel were blinded to point-of-care test results.
Risk of bias: Could the reference standard, its conduct, or its interpretation have introduced bias?	Low	Despite no mention of blinding, the reference methods are objective and not likely influenced by index test or intervention results.
B. Concerns regarding applicability		
Applicability: Is there concern that the target condition as defined by the reference standard does not match the review question?	Low	The test reflects real-world point of care drug-checking practices.
Domain 4: Flow and timing		
A. Risk of bias		
Was there an appropriate interval between index test(s) and reference standard?	Yes	Confirmatory testing followed index testing within a reasonable time frame.
Did all samples receive a reference standard?	No	Only a subset of samples underwent confirmatory testing.
Did samples receive the same reference standard?	Yes	Confirmatory testing was standardized using laboratory-based analysis.
Were all samples included in the analysis?	Yes	All tested samples were included in the analysis.
Risk of bias: Could the sample flow have introduced bias?	High	Analysis was conducted on a subset of all samples, possibly introducing selection bias.

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; LC-MS = liquid chromatography–mass spectrometry; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2.

^aThe appraisal applies to all the index tests or interventions in the study.

Table 25: Strengths and Limitations of Cost Description Study Guided by the Relevant Domains of the Drummond Checklist³⁵

Strengths	Limitations
Cepeda et al. (2023)⁵²	
Study design The research question was explicitly stated, and its	Data collection Results section is heavily focused on FTIR cost details. More

Strengths	Limitations
economic importance was clearly justified within the context of the opioid crisis. • The viewpoint of the analysis (payer perspective) was clearly stated and appropriate for informing implementation costs. Data collection • The choice of method supports transparency and reproducibility in cost estimation for future scaleup. • Resource quantities and unit costs were clearly reported, separated, and itemized (e.g., salaries, equipment, space, training). • Equipment costs were annualized using a salvage value approach, demonstrating methodological rigour. • Sensitivity analyses were performed with justified variables and ranges (US\$10,000 to US\$15,000). • Primary outcome (cost per drug checked) was clearly defined and supported by disaggregated cost breakdowns. • Major cost drivers, such as equipment and training, were identified and discussed in context. Analysis and interpretation of results • The study presented costs both in aggregate and by component, aiding understanding of economic drivers. • The answer to the study question was clearly stated (US\$474 per sample). • Conclusions were aligned with the data and included reasonable caveats. • The time horizon was explicitly stated and fit the scope of a pilot implementation.	details on fentanyl test strips and confirmatory testing would improve the results. • Reliance on in-kind training support may underestimate real-world implementation costs. Other • The findings may have limited generalizability outside academic or well-supported pilot contexts. • Potential conflicts of interest or funding bias were not explicitly discussed.

FTIR = Fourier transform infrared.

Appendix 5: Main Study Findings

Table 26: Summary of Findings by Study —Test Accuracy for the Detection of Fentanyl and Analogues

Author (year)	Target substances; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Crepeault et al. (2023) ³⁷	Fentanyl and its analogues; 1,467	qNMR, GC-MS, or LC-MS	FTS	NR	NR	Fentanyl: 6% ^{ab} Carfentanil: 23% Acetyl fentanyl: 7% Furanyl fentanyl: 11% Cyclopropyl fentanyl: 0%	NR	Fentanyl: 94 ^{ab} (NR) Carfentanil: 77 (NR) Acetyl fentanyl: 93 (NR) Furanyl fentanyl: 89 (NR) Cyclopropyl fentanyl: 100 (NR)	NR
			FTIR	NR	NR	Fentanyl: 38% ^{ab} Carfentanil: 100% Acetyl fentanyl: 100% Furanyl fentanyl: 100% Cyclopropyl fentanyl: 100%	NR	Fentanyl: 62 ^{ab} (NR) Carfentanil: 0 (NR) Acetyl fentanyl: 0 (NR) Furanyl fentanyl: 0 (NR) Cyclopropyl fentanyl: 0 (NR)	NR

Author (year)	Target substances; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Estrada et al. (2025) ³⁸	Fentanyl in opioid samples; total sample = 1,644 (908 opioids samples)	GC-MS or LC-QTOF-MS	FTS	NR	NR	NR	NR	NR	NR
			FTIR	NR	NR	NR	NR	NR	NR
	Fentanyl in cocaine samples; total sample = 1,644 (314 cocaine)	GC-MS, LC-QTOF-MS	FTS	NR	8	NR	NR	NR	NR
			FTIR	0	1	0	308	NA	99.6% ^a (NR)
	Fentanyl in methamphetamine samples; total sample = 1,644 (62 methamphetamine)	GC-MS, LC-QTOF-MS	FTS	NR	0	NR	59	100% ^a (NR)	100% ^a (NR)
			FTIR	0	0%	0	62	NA	100% ^a (NR)
	Fentanyl in benzodiazepine Samples; total sample = 1,644 (59 benzodiazepine)	GC-MS, LC-QTOF-MS	FTS	0	1	0 ^a	58	100% ^a (NR)	98% ^a (NR)
			FTIR	0	0	0% ^a	59	NA	100% ^a (NR)
Gozdzialski et al. (2021) ⁴²	Carfentanil in opioid samples; 59	PS-MS	Portable GC-MS	NR	NR	38% ^a (for fentanyl: 5%) ^a	NR	62 (NR) (for fentanyl: 95 (NR))	NR

Author (year)	Target substances; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
			FTIR	NR	NR	100 ^a % (for fentanyl: 9%) ^a	NR	0 (NR) (for fentanyl: 91 (NR))	NR
Green et al. (2020) ³⁰	Fentanyl analogues; 210: 104 in Baltimore, 106 in RI lab	GC-MS	FTS	NR	Against Baltimore lab: 1.9% ^a Against RI lab: 9.6% ^a	Against Baltimore lab: 0% ^a Against RI lab: 3.7% ^a	NR	Against Baltimore lab: 100 (NR) Against RI lab: 96.3 (NR)	Against Baltimore lab: 98.1 (NR) Against RI lab: 90.4 (NR)
			FTIR	NR	Against RI lab: NA Against RI lab: 9.3% ^a	Against Baltimore lab: NA Against RI lab: 16.7% ^a	NR	Against Baltimore lab: NA Against RI lab: 83.3 (NR) For all present substances: 81.9 (NR) For samples not containing fentanyl: 80.4 (NR)	Against Baltimore lab: NA Against RI lab: 90.2 (NR)
			Raman spectrometer-point-and-shoot mode	NR	Against Baltimore lab: 1.9% ^a Against RI lab: 0% ^a	Against Baltimore lab: 96.2% ^a Against RI lab: 96.3% ^a For all present substances: 74.3% ^a	NR	Against Baltimore lab: 3.8 (NR) Against RI lab: 3.7 (NR) For all present substances: 25.7 (NR)	Against Baltimore lab: 98.1 (NR) Against RI lab: 100 (NR)

Author (year)	Target substances; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
						For samples not containing fentanyl: 51.9% ^a		For samples not containing fentanyl: 48.1 (NR)	
			Raman spectrometer-SERS kit	NR	Against Baltimore lab: 7.7% ^a Against RI lab: 8.5% ^a	Against Baltimore lab: 61.5% ^a Against RI lab: 38.9% ^a For all present substances: 46.2% ^a For samples not containing fentanyl: 42.3% ^a	NR	Against Baltimore lab: 38.5 (NR) Against RI lab: 61.1 (NR) For all present substances: 53.8 (NR) For samples not containing fentanyl: 57.7 (NR)	Against Baltimore lab: 92.3 (NR) Against RI lab: 91.5 (NR)
Park et al. (2024) ^{44,c}	Fentanyl; ^d 125	GC-MS, LC-QTOF-MS	FTS	NR	NR	NR	NR	NR	NR
			FTIR	NR	NR	NR	NR	NR	NR
Park et al. (2022) ⁴⁵	Fentanyl and its analogues in total samples; ^e 343	LC-MS-MS	FTS	NR	10.9%	1.5%	NR	98.5 (NR)	89.2 (NR)
	Fentanyl and analogues in cocaine samples; 72	LC-MS-MS	FTS	NR	3%	0%	NR	100 (NR)	97 (NR)

Author (year)	Target substances; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
	Fentanyl and analogues in PO (oxycodone, tramadol, morphine) samples; 40	LC-MS-MS	FTS	NR	9.5%	0%	NR	100 (NR)	90 (NR)
	Fentanyl and analogues in methamphetamine samples; 25	LC-MS-MS	FTS	NR	0%	NA	NR	NA	100 (NR)
	Fentanyl and analogues in prescription benzodiazepines (alprazolam, clonazepam) samples; 10	LC-MS-MS	FTS	NR	0%	NA	NR	NA	100 (NR)
	Fentanyl and analogues in synthetic cathinones samples (eutylone); 17	LC-MS-MS	FTS	NR	0%	NA	NR	NA	100 (NR)
	Fentanyl and analogues in heroin samples; 47	LC-MS-MS	FTS	NR	NA	0%	NR	100 (NR)	NA
	Fentanyl and analogues in cannabinoids (delta-9-THC,	LC-MS-MS	FTS	NR	4%	NA	NR	NA	96 (NR)

Author (year)	Target substances; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
	cannabinoid) samples; 26								
	Fentanyl and analogues in 4-ANPP (fentanyl precursor) samples; 87	LC-MS-MS	FTS	NR	NA	1.1%	NR	98.9 (NR)	NA
Ti et al. (2020) ^{23,f}	Fentanyl and analogues; 331	qNMR, GC-MS	FTS	NR	4.8% ^a	12.5%	NR	87.5 (82.8 to 92.2)	95.2 (87.6 to 99.4)
			FTIR	NR	1% ^a	27.9%	NR	72.1 (65.9 to 78.3)	99.0 (93.6 to 100.0)

FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; LC-MS = liquid chromatography–mass spectrometry; LC-MS-MS = high-precision liquid chromatography–tandem mass spectrometry; LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; NA = not applicable; NR = not reported; NPV = negative predictive value; NR = not reported; PPV = positive predictive value; PS-MS = paper spray mass spectrometry; qNMR = quantitative nuclear magnetic resonance; RI = Rhode Island; RS = reference standard; RS-point = Raman spectroscopy point; SERS = surface-enhanced Raman spectroscopy; TN = true negative; TP = true positive.

Note: This table has not been copy-edited.

^aCalculated based on the provided data in the study.

^bThe authors of this study reported a portion of the FTS and FTIR results (i.e., 801) for all positives obtained by the confirmatory lab testing (i.e., 855). We calculated the sensitivity and FN based on 801 samples that were explicitly reported in the study.

^cThe authors of this study reported that 33.9% and 36.8% of samples tested positive for fentanyl using FTIR spectroscopy and laboratory testing, respectively. The concordance between FTIR spectroscopy and laboratory-confirmed fentanyl was $\kappa = 0.96$ ($Z = 10.38$, $P < 0.001$).

^dTarget substance of the study was xylazine, but they also reported results on fentanyl.

^eThe analysis excluded 5 samples that only contained novel fentanyl analogues that were not designed to be detected by either the FTS or GC-MS: para-Fluorobutyryl fentanyl / 4-FBF / FBF; para-Fluoroisobutyrylfentanyl / 4-FIBF / FIBF; Para-chloroisobutyryl fentanyl / ClBF.

^fThis study also reported the following outcomes for accuracy: PPV = 98.1% (95% CI 94.8 to 99.8) and NPV = 73.4% (95% CI 64.2 to 82.6) for FTS; PPV = 99.4% (95% CI 96.2 to 100) and NPV = 59.9% (95% CI 51.7 to 68.0) for FTIR spectroscopy; Concordance $\kappa = 0.69$ for FTS and qNMR/GC-MS and $\kappa = 0.60$ for FTIR spectroscopy and qNMR/GC-MS, suggesting “substantial and moderate agreement,” respectively, according to Landis and Koch’s classifications.²³

Table 27: Summary of Findings by Study —Test Accuracy for the Detection of Benzodiazepine and Analogues

Author (year)	Target substance; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Crepeault et al. (2025) ^{36,b}	Benzodiazepines and analogues in any sample; 1922	qNMR, GC-MS, LC-MS	BTS	NR	18% ^a	33% ^a	NR	67 (62 to 72)	82 (79 to 85)
			FTIR	NR	1% ^a	74% ^a	NR	26 (22 to 31)	99 (99 to 100)
			BTS (excluding etizolam)	NR	17% ^a	2% ^a	NR	98 (94 to 99)	83 (81 to 86)
			BTS and FTIR combined	NR	18% ^a	25% ^a	NR	75 (70 to 79)	82 (79 to 84)
Gozdzialski et al. (2022) ⁴¹	Etizolam in opioid drug mixture; 509 (of these, 100 samples were analyzed with SERS)	PS-MS	BTS ^c	4	0 (0%) ^a	46 (92%) ^a	48	8 (NR)	100 (NR)
			SERS	48	7 (14%) ^a	2 (4%) ^a	43	96 (NR)	86 (NR)
Gozdzialski et al. (2021) ⁴²	Etizolam in opioid samples; 59	PS-MS	Portable GC-MS	NR	NR	64% ^a in all samples 22% ^a in samples with concentrations of more than 3%	NR	36 (NR) in all samples 78 (NR) in samples with concentrations of more than 3% (NR)	NR
			FTIR	NR	NR	91% ^a	NR	9 (NR)	NR
Laing et al. (2021) ⁴³	Benzodiazepines, in opioids samples; 159	GC-MS, LC-MS, qNMR	BTS	NR	15.5%	37.5%	NR	62.5 ^a (NR)	84.5 ^a (NR)

Author (year)	Target substance; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Tobias et al. (2021) ⁴⁹	Alprazolam; 20 ^d	GC-MS	FTIR	NR	3.9%	91.7%	NR	8.3 ^a (NR)	96.1 ^a (NR)
			BTS and FTIR combined	NR	17.8%	29.2%	NR	70.8 ^a	82.2 ^a
			FTS ^e	0	3	6	0	NA	NA
			BTS	5	33% ^a	0% ^a	12	100 ^{af} (NR)	67 ^{ag} (NR)
			FTIR	1	0% ^a	83% ^a	14	17 ^a (NR)	100 ^a (NR)

BTS = benzodiazepine test strips; FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; LC-MS = liquid chromatography–mass spectrometry; NA = not applicable; NR = not reported; NPV = negative predictive value; PPV = positive predictive value; PS-MS = paper spray mass spectrometry; qNMR = quantitative nuclear magnetic resonance; RS = reference standard; SERS = surface-enhanced Raman spectroscopy; TN = true negative; TP = true positive.

Note: This table has not been copy-edited.

^aCalculated by authors of this report based on the available data in the included studies.

^bThis study also reported the following outcomes for accuracy: PPV = 62% (57 to 67) and NPV = 85% (82 to 87) for BTS; PPV = 91% (84 to 96) and NPV = 83% (81 to 85) for FTIR spectroscopy; and PPV = 65% (60 to 69) and NPV = 88% (86 to 90) for BTS and FTIR spectroscopy combined.

^cIn 2 of the samples that underwent testing with SERS, the benzo test strip data were absent and therefore n = 98 in this case.

^dOf 20 samples tested on GC-MS (confirmatory lab testing), 18 had corresponding BTS results.

^eFTS testing was used as part of the point-of-care services. The samples that resulted in FP on FTS had fentanyl or fentanyl analogues.

^fCalculation of Sensitivity is based on 5 TP BTS results given that 1 positive result on GC-MS (confirmatory lab testing) did not have a corresponding BTS result.

^gCalculation of Specificity is based on 12 TN BTS results given that 2 samples tested on GC-MS (confirmatory lab testing) did not have a corresponding BTS result.

Table 28: Summary of Findings by Study —Test Accuracy for the Detection of Xylazine and Analogues

Author (year)	Target substance; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Park et al. (2024) ^{44,a}	Xylazine; 125	GC-MS, LC-QTOF-MS	FTIR	NR	NR	46 ^{bc}	NR	54 ^{bc}	NR
Sisco et al. (2024) ⁴⁶	Xylazine; 100	DART-MS, GC-MS-MS	XTS	NR	0% ^b	2.6% ^b	NR	97.4 (NR)	100 (NR)
Thompson et al. (2024) ⁴⁸	Xylazine; 41	LC-QTOF-MS	XTS	NR	0%	77.8%	NR	22.2 (NR)	100 (NR)
Tobias et al. (2020) ⁵⁰	Xylazine; 83	GC-MS	FTS	0	NR	NR	NR	NR	NR
			FTIR	0	NR	100 ^b	NR	0 ^d (NR)	NR

DART-MS = direct analysis in real time mass spectrometry; FTIR = Fourier transform infrared; GC-MS = gas chromatography–mass spectrometry; GC-MS-MS = gas chromatography–tandem mass spectrometry; FTS = fentanyl test strips; LC-QTOF-MS = liquid chromatography–quadrupole time-of-flight mass spectrometry; LC-MS-MS = high-precision liquid chromatography–tandem mass spectrometry; NR = not reported; RS = reference standard; XTS = xylazine test strips; NPV = negative predictive value; PPV = positive predictive value; TN = true negative; TP = true positive.

Note: This table has not been copy-edited.

^aThis study also reported that the concordance between FTIR spectroscopy and laboratory-confirmed fentanyl was 0.74 (Z = 8.18, P < 0.001).

^bCalculated by authors of this report based on the available data in the included studies.

^cThe calculations done for this study are based on 26 substance samples tested positive for xylazine in laboratory testing presented in [Table 3](#) (page 5 of the manuscript).

^dThis number increased to 100% of the time if xylazine was a major active component.

Table 29: Summary of Findings by Study — Test Accuracy for the Detection of Other Compositions

Author (year)	Target substance; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Fregonese et al. (2021) ³⁹	Any composition in unidentified substances; 120	GC-MC	Colorimetric reagent	Ketamine: 25 MDMA: 28 Amphetamine: 10 Cocaine: 11 Heroin: 7 LSD: 4 Mephedrone: 0 MIX: ^a 0 Debris: ^b 0 Methamphetamine: 0 Unknown: 29	NR	Ketamine: 22% ^c MDMA: 16% ^c Amphetamine: 9% ^c Cocaine: 8% ^c Heroin: 12% ^c LSD: 0% ^c Mephedrone: 100% ^c MIX: ^a 100% ^c Debris: ^b 100% ^c Methamphetamine: 100% ^c	NR	Ketamine: 78 (NR) MDMA: 84 (NR) Amphetamine: 91 (NR) Cocaine: 92 (NR) Heroin: 88 (NR) LSD: 100 (NR) Mephedrone: 0 (NR) MIX: ^a 0 (NR) Debris: ^b 0 (NR) Methamphetamine: 0 (NR)	NR
Goncalves et al. (2021) ^{40,d}	Any submitted substance sample; 163	LC-QTOF	IR	Cocaine: 38 MDMA: 33 Amphetamine: 14 Heroin: 6 Caffeine: 12 Paracetamol: 11	Cocaine: 0% ^c MDMA: 0% ^c Amphetamine: 0% ^c Heroin: 0% ^c Caffeine: 0% ^c Paracetamol: 0% ^c	Cocaine: 0% MDMA: 13.2% Amphetamine: 17.6% Heroin: 50% Caffeine: 36.8% ^c Paracetamol: 15.4% ^c	NR	Cocaine: 100 (NR) MDMA: 86.8 (NR) Amphetamine: 82.4 (NR) Heroin: 50 (NR) Caffeine: 63.2 (NR) Paracetamol: 84.6 (NR)	Cocaine: 100 (NR) MDMA: 100 (NR) Amphetamine: 100 (NR) Heroin: 100 (NR) Caffeine: 100 (NR)

Author (year)	Target substance; number of samples underwent confirmatory lab testing	Confirmatory lab testing	Index test(s) or intervention(s)	TP (n, unless specified with a %)	FP (n, unless specified with a %)	FN (n, unless specified with a %)	TN (n, unless specified with a %)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
									Paracetamol: 100 (NR)
Ti et al. (2021) ⁴⁷	Synthetic cannabinoid; 909	GC-MS, LC-MS	FTS	NR	NR	NR	NR	NR	NR
			FTIR	13	NR	12 (48% ^c)	NR	52 ^c (NR)	NR
Whitehead et al. (2023) ⁵¹	22 illicit drugs and cutting agents; 124	LC-MS-MS	FTS	NR	0%	5%	NR	95 ^c (NR)	100 ^c (NR)
			BTS ^e	NR	NR	NR	NR	NR	NR

BTS = benzodiazepine test strips; FTIR = Fourier transform infrared; FTS = fentanyl test strip; GC-MS = gas chromatography–mass spectrometry; IR = infrared spectroscopy; LC-MS = liquid chromatography–mass spectrometry; LC-MS-MS = high-precision liquid chromatography–tandem mass spectrometry; LC-QTOF = liquid chromatography–quadrupole time-of-flight mass spectrometry; LSD = lysergic acid diethylamide; MDMA = methylenedioxymethamphetamine; NA = not applicable; NPV = negative predictive value; NR = not reported; PPV = positive predictive value; RS = reference standard; TN = true negative; TP = true positive.

Note: This table has not been copy-edited.

^aMIX: samples with mixtures of substances, in which the substances were present in approximately equal quantities and had similar pharmacological activities.

^bDebris: a sample that was found to be free of active substances.

^cCalculated by authors of this report based on the available data in the included studies.

^dThis study also reported the following outcomes for accuracy of IR vs. LC-QTOF: PPV for Cocaine = 100% (NR), MDMA = 100% (NR), Amphetamine = 100% (NR), Heroin = 100% (NR), Caffeine = 100% (NR), Paracetamol = 100% (NR); and NPV for Cocaine: 100% (NR) MDMA = 93.2% (NR) Amphetamine = 97.5% (NR) Heroin = 98.5% (NR) Caffeine = 94.4% (NR) Paracetamol = 98.4% (NR).

^eThe author stated that ‘a comparison of the results from BTS to LC-MS-MS could not be made as all samples but 1 tested negative on BTS. For the 1 sample that showed a positive BTS, none of the 4 benzodiazepines included in this LC-MS-MS method were quantified in that sample.’

Table 30: Summary of Findings by Study — Limit of Detection

Author (year)	Target substance	Reference standard and confirmatory lab testing	Index test(s)/ intervention(s)	Minimum concentration detected	Note
Crepeault et al. (2025) ³⁶	Benzodiazepine and its analogues	qNMR ^a	FTIR	> 10% by weight	All samples containing benzodiazepines were not detected by FTIR spectroscopy in concentrations of less than 10%.
			BTS	Inconsistent	Did not detect any benzodiazepine in 25% of samples found to contain a benzodiazepine via qNMR spectroscopy, potentially because of the cross-reactivity of etizolam with BTS. After removing etizolam (n = 122), only 1 sample containing flualprazolam detected through qNMR spectroscopy was negative on BTS and had a concentration of 2%.
Gozdzialski et al. (2021) ⁴²	Carfentanil and etizolam	PS-MS	Portable GC-MS	3% by weight for etizolam 0.13% to 0.63% by weight for carfentanil	At concentrations of more than 3%, the portable GC-MS was able to detect 78% of the etizolam samples that were confirmed by PS-MS. Portable GC-MS detected carfentanil at much lower concentrations (0.13% to 0.63%).
			FTIR	NR for etizolam None for carfentanil	9% of samples containing etizolam (as detected by PS-MS) were detected with FTIR. No instances of carfentanil as detected by PS-MS were detected with FTIR.
Green et al. (2020) ³⁰	Fentanyl analogues	Powder fentanyl standards	FTS	0.100 mcg/mL in both labs	LOD was the lowest concentration at which fentanyl was detected.
			Hand-held Raman spectrometer	25 mcg/mL in RI lab ^b	LOD was the lowest concentration at which fentanyl was detected.
			FTIR	3% to 4% by weight in RI lab ^c	The FTIR spectroscopy detected samples according to weight, indicating that, for a given powder or pill tested containing fentanyl, the smallest detectable amount for fentanyl is 3% to 4% weight.

Author (year)	Target substance	Reference standard and confirmatory lab testing	Index test(s)/ intervention(s)	Minimum concentration detected	Note
			GC-MS	3.1 mcg/mL in RI lab 100 mcg/mL in Baltimore lab	LOD was the lowest concentration at which fentanyl was detected.
McCrae et al. (2020) ⁵³	Fentanyl and its analogues	qNMR ^d	FTS	> 5% by weight	Fentanyl was consistently detected at concentrations less than 5% by weight.
			FTIR	> 10% by weight	Fentanyl was consistently detected at concentrations less than 10% by weight.
Park et al. (2022) ⁴⁵	Fentanyl and its analogues	Laboratory-grade fentanyl and high-priority fentanyl analogues	FTS	≥ 200 ng/mL for fentanyl ≤ 1,000 ng/mL for 13 analogues (among 17 analogues tested)	LOD was the lowest concentration at which fentanyl was detected.
Sisco et al. (2024) ⁴⁶	Xylazine	Pure xylazine (laboratory samples)	XTS	≥ 2.5 mcg/mL (2,500 ng/mL)	LOD was the lowest concentration at which fentanyl was detected.
Whitehead et al. (2023) ⁵¹	Fentanyl	Fentanyl concentrations diluted in water and in the extraction solvent	FTS	100 ng/mL	LOD was the lowest concentration at which fentanyl was detected.

BTS = benzodiazepine test strips; FTIR = Fourier transform infrared; FTS = fentanyl test strips; GC-MS = gas chromatography–mass spectrometry; NA = not applicable; NR = not reported; RI = Rhode Island; RS = reference standard; qNMR = quantitative nuclear magnetic resonance; XTS = xylazine test strips.

Note: This table has not been copy-edited.

^aAnalysis by qNMR spectroscopy detected benzodiazepine in samples ranging in concentration from 1.0% to 100%. Therefore, we could not know from this study if they could detect samples with lower concentrations than 1.0%.

^bThis article stated that “the Raman spectrometer was tested in both labs, however due to changes in the software library, results were deemed reliable only in the Rhode Island data.”

^cBruker ALPHA FTIR spectroscopy was tested only in Rhode Island laboratory.

^dAnalysis by qNMR spectroscopy detected fentanyl in samples ranging in concentration from 1.0% to 91.0% by weight. Therefore, we could not know from this study if they could detect samples with lower concentrations than 1.0%.

Table 31: Summary of Findings by Study — Reproducibility

Author (year)	Type of precision	Index test(s) or intervention(s)	Concentrations	N replicates	Outcome
Sisco et al. (2024) ⁴⁶	Consistency across days	XTS, N = 20	Positive control: xylazine solution with a concentration of 5,000 mcg/mL Negative control: water	2 × day over a 6-week period	XTS used to analyze the 5,000 mcg/mL xylazine solution consistently produced clear positive results. XTS used to analyze the water with no xylazine consistently produced clear negative results.
Sisco et al. (2024) ⁴⁶	Consistent detection near LOD	XTS, N = 15 per concentration	Xylazine concentrations of 0, 0.1, 0.5, 1, 2.5, 5, 10, 25, 50, 100, 500, 1,000, and 5,000 mcg/mL (water)	4 different days	The approximate LOD, where consistent positive results could be obtained, was found to be 2.5 mcg/mL (2,500 ng/mL).

LOD = limit of detection; XTS = xylazine test strips.

Note: This table has not been copy-edited.

Table 32: Summary of Findings of Included Cost Description Study

Main study findings	Authors' conclusion
Cepeda (2023)⁵²	
Total cost during study period was US\$71,044: 77% Equipment and other start-up: 54% attributed to the FTIR machine, software, libraries, and technical training 23% other equipment and start-up expenses 16% attributed to personnel, which consisted of a program director, FTIR technician (who held a bachelor's degree in a scientific field), research assistant, outreach worker, and administrative assistant 4% attributed to training, which involved ≈ 80 hours of technical assistance, in-person training, and independent practice 3% nonpersonnel recurrent The cost per drug checked: US\$474 (including confirmatory testing: US\$150 per sample) - In real-world implementation, possibly 10% to 25% of samples may need to be checked for ongoing quality assurance, which would result in a range from US\$339 to US\$361 per drug checked after the establishment of the program. In sensitivity analyses, which incorporated estimated at-cost training supports (US\$10,000 to US\$15,000): - The total cost of the program over this period would increase to US\$78,058 to US\$83,058	"These findings demonstrate feasibility and inform the resources needed to scaleup drug checking services to reduce overdose risk."⁵² "While the unit cost of FTS and reagents are substantially less using FTIR spectroscopy, major advantages of FTIR spectroscopy over FTS and reagents are its ability to adapt to the evolving drug market, identify multiple substances in a sample as well as their relative presence, nondestructive method, and involvement of a trained technician."⁵²

Main study findings	Authors' conclusion
• Cost per drug checked increases, ranging from US\$544 to US\$593.	

FTIR = Fourier transform infrared; FTS = fentanyl test strips.

Note: This table has not been copy-edited.

Appendix 6: Study Findings From Surveys Completed by DCT Manufacturers

Please note that this appendix has not been copy-edited.

Table 33: Costs and Capabilities of Immunoassay Test Strip Drug-Checking Technologies

Costs and capabilities	The Rapid Response [fentanyl, xylazine, medetomidine, nitazene and benzodiazepine] test strips - liquid/powder (BTNX) ^a	Fentanyl and xylazine test strips (WHPM Inc.) ^b
Type		
Drug-checking technique	Lateral Flow Immunoassay strips (Responses from BTNX summarized in this column applicable for 5 different test strips to detect different substances, including fentanyl, xylazine, medetomidine, nitazene, benzodiazepine; responses from BTNX presented under the same column)	Immunoassay Test Strip (Responses from WHPM, Inc. summarized in this column) applicable for test strips for detecting 2 different substances: fentanyl [i.e., fentanyl test strip] and xylazine [i.e., xylazine test strip])
Time to result		
Time required for DCT to provide results	< 5 minutes	3 to 5 minutes
Pricing and fees		
Total purchase price of DCT (CA\$)	CA\$1.00 to CA\$3.00 per strip depending on the type and quantity. Sold in packs of 5, 10, 100 plus shipping.	CA\$1.15 plus shipping
Inclusions in the purchase price	Test strip Online support	Test strip/microscope
Ongoing operational costs (e.g., consumables, reagents, test cartridges, maintenance)?	None	None
Subscription or licensing fees	No	No
Pricing for bulk purchases or for community-based organizations	Yes	Yes
Financing option	No	Yes
Leasing option	No	No
Rental option	No	No
Warranty	No	No
Servicing and support		
Servicing DCT	Not applicable	Not applicable

Costs and capabilities	The Rapid Response [fentanyl, xylazine, medetomidine, nitazene and benzodiazepine] test strips - liquid/powder (BTNX)^a	Fentanyl and xylazine test strips (WHPM Inc.)^b
Expected service and maintenance costs	Not applicable	Not applicable
Unique IT considerations applicable to DCT (e.g., cybersecurity)	Not applicable	Not applicable
Access to DCT support	Through phone call, email, talking to agent	Not applicable
Typical response time	24 to 48 hours, no fee	Not applicable
Technical or user support included in the base purchase price?	BTNX customer support team always available	Not applicable
Any additional cost associated with unique IT support (e.g., cybersecurity considerations)?	No	Not applicable
If not, what are the additional support-related fees?	Not applicable	Not applicable
Training and staffing		
Qualifications or training required to operate DCT	No training. Only need to follow package insert. BTNX support still available to answer any questions.	"None, designed for lay user"
Training costs	Not applicable	Not applicable
Portability and infrastructure needs		
Physical space requirements for DCT	Exact measurements not reported (small, size of test strip)	Paper width 120 mm x 60 mm
Portability and Durability (e.g., can it be used outdoors)?	Yes, it can be used anywhere. Preferably to be used at operating temperatures of 15 to 30°C	Yes, portable, undergone FDA prescribed flex studies for durability. May be used outdoors in ambient temperature.
Can DCT be used in a vehicle?	Yes, already used in Mobile vans internationally	Yes, provided a flat, dry surface.
If DCT can be used in a vehicle, what are the specific considerations for mobile deployment?	Only to store strips at 2°C to 30°C and use at 15°C to 30°C	Not applicable
Compatibility		
Should DCT be used in combination with test strips?	Not applicable	The device is a visually read test strip
If DCT should be used in combination with test strips, which ones?	Not applicable	Not applicable

Costs and capabilities	The Rapid Response [fentanyl, xylazine, medetomidine, nitazene and benzodiazepine] test strips - liquid//powder (BTNX) ^a	Fentanyl and xylazine test strips (WHPM Inc.) ^b
If DCT should be used in combination with test strips, are there added costs?	Not applicable	Not applicable
Company information		
Company website	https://www.btnx.com/	https://www.whpm.com/harm-reduction-tests
Company based in Canada	Yes	No

CA\$ = Canadian dollars; DCT = drug-checking technology.

^aKhasim Ali Khan, MSc, Technical Operations Director, BTNX: email communication, July 11, 2025.

^bChristopher M. Patterson, Vice-President, Product Development and Marketing, WHPM, Inc.: email communication, July 9, 2025.

Table 34: Costs and Capabilities of Raman and Near-Infrared Spectroscopy Drug-Checking Technologies

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
Device type							
Drug-checking technique	Fourier transform infrared spectroscopy	Raman spectroscopy	Spectrum matrix analysis and Raman spectroscopy	Raman spectroscopy	Near-Infrared Spectroscopy	Raman spectroscopy and surface-enhanced Raman spectroscopy (SERS)	Fourier transform infrared spectroscopy
Time to result							
Time required for DCT to provide results	< 2 minutes	Approximately 6 to 10 seconds	Approximately 6 to 10 seconds	2 to 15 minutes	5 to 10 seconds	Bulk scan: average 90 seconds; Trace scan: 5 to 10 minutes; bulk scan can be done in parallel with trace scan preparation steps to optimize result time	< 1 minute
Pricing and fees							
Total purchase price of DCT (CA\$)	Depends on the instrument (ALPHA II or MOBILE-IR II) and configuration	Not provided or confidential	Not provided or confidential	Not provided or confidential	Not provided or confidential	CA\$32,000	Not provided or confidential
Inclusions in the purchase price	Online support. Complete package includes instrument; carrying case, notebook computer,	Software updates or database/library upgrades Online support 1 year warranty	Software updates or database/library upgrades Online support 1 year warranty	Not provided or confidential	Software updates or database/library upgrades Online support Hardware	Software updates or database/library upgrades. Online support. Ruggedized carry case, all sampling attachments	Not provided or confidential

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
	software, reference libraries, installation, training					and electronics accessories, virtual training included, 1 year of warranty and Reachback service (advanced analytical support)	
Ongoing operational costs (e.g., consumables, reagents, test cartridges, maintenance)?	Desiccant refills (can also be dried and reused)	Consumable reagent pouches are CA\$33.78 to CA\$54.10 per 10 count box. No maintenance costs.	Consumable reagent pouches are CA\$13.50 per 10 count box. No maintenance costs.	< CA\$100 per year	None	CA\$12 to 15 per trace scan cartridge (no cost for Bulk Scan mode)	FTIR are considered almost maintenance free. The desiccant recharge can be done by the lab personnel
Subscription or licensing fees	No, most purchasers buy software and reference libraries on licence that does not expire. Subscription licences are available for software at a lower initial cost, if desired. Software updates are available (not mandatory), typically costing CA\$2,000 to CA\$4,000 depending on item.	No	No	Yes; CA\$10,000 annually	Yes; yearly licence per device	Included in extended warranty (billing frequency: annually or monthly)	No

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
Pricing for bulk purchases or for community-based organizations	Not reported	Yes; multiple units qualify for a discount per unit	Yes; multiple units qualify for a discount per unit	Yes	Yes; a quantity discount applies	Yes	Yes: bundled pricing can be negotiated
Financing option	Yes	No	No	Yes	No	No	Yes
Leasing option	Yes	No	No	No	No	No	Yes
Rental option	No	No	No	Yes	Yes	Yes	Yes
Warranty	Yes. One year comprehensive parts and labour; warranty extensions are often included for no additional charge on key components of the system, e.g., interferometer, laser, source, Diamond ATR	Included: 1 year warranty Subsequent years CA\$2,645.00 each	Included: 1 year warranty Subsequent years CA\$4,542.50 each	1 year warranty, covers all nonuser error damages	Not provided or confidential	1 year warranty. CA\$3,500 for each additional year	Yes. Basic warranty covers 1 year parts and labour plus 10 years coverage on Interferometer and Source and 5 Years on Laser. Extended warranty could be offered at CA\$5,000.00 per year
Servicing and support							
Servicing DCT	Provide field service engineers who do installations and support. Return to service depot (in US or Germany) is sometimes necessary if field	Remotely when possible. Return for repair via Return Merchandise Authorization when needed	Remotely when possible. Return for repair via Return Merchandise Authorization when needed	In-house servicing	The NIRLAB device requires no routine maintenance. The sapphire window and internal lamp are the only components that may need replacement in	The vast majority of technical challenges get serviced remotely; if a physical repair is needed, Spectra Plasmonics will ship a loaner unit to the customer in	Remote support if required, available 5 days a week from 8 a.m. to 5 p.m. EST using the 1-800 number. Onsite support through a ticket or call to our service help desk with s

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
	service cannot repair the system.				case of damage. The device is rugged, water- and dust-resistant (IP65/IP67 rated), and designed for long-term field use with minimal servicing needs. NIRLAB recommends cleaning the sapphire window regularly with alcohol and a tissue to ensure optimal measurement accuracy. Calibration is software-guided and performed by the user with the supplied reflectance reference standard.	the interim while device is repaired	certified service engineer
Expected service and maintenance costs	CA\$310 per year for desiccant if you don't dry/recycle desiccant packs. After 5 years a new IR source will be needed,	Cost of keeping the battery charged. Nominal. Similar to a smartphone.	Cost of keeping the battery charged. Nominal.	< CA\$500/year	Not reported	CA\$0, if covered under extended warranty	Not reported

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
	cost is about CA\$800. These items are available through the Bruker web store or by contacting Bruker Ltd., Milton, ON, Canada: 905-876-4641.						
Unique IT considerations applicable to DCT (e.g., cybersecurity)	Same as a Windows 10 or 11 computer	User access control: The user only has access to results unless exported.	User access control: The user only has access to results unless exported.	Web Bluetooth, Internet of Things devices	The NIRLAB ecosystem has been designed with data security and user privacy as a core priority. Key IT and cybersecurity aspects: Secured Cloud Infrastructure: All data are stored on encrypted servers hosted at a secured data centre in Switzerland. The cloud solution allows for constant updates and an ever evolving, enhanced method. Encrypted Communication:	Spectral processing and data app is hosted on cloud (data can be downloaded)	Not reported

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
					The communication between the mobile app and the server is fully encrypted, ensuring the safe transmission of sensitive information. User Access Control: The system includes role-based access management to restrict data visibility within organizations. No Sensitive Personal Data Stored: Scan data are anonymized — sample names are coded, and no suspect or individual-related information is stored. Offline Capability: The device can operate offline, with scans stored locally and synchronized securely once		

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
					reconnected. Geolocation Controls: Geolocation tagging can be activated or deactivated by the user, depending on operational or legal requirements.		
Access to DCT support	Bruker Support through our webpage or call centre; directly calling or emailing Bruker staff.	24hr support number, support email.	24hr support number, support email.	9am to 5pm support, reach back support.	Support is provided through the following channels: Email and Phone Support: Available for technical assistance, troubleshooting, and general inquiries. Onboarding and Training: Offer remote onboarding sessions to ensure users are confident in using the device and software. In-App Guidance: Both the mobile and web applications include built-in tool tips and calibration	Customer support email and phone line.	Offer e-learning, a 1-800 number for service-related questions, an application chemist can be contacted by email or provide remote support on the application, cloud for service software for entering service tickets for onsite support, the sales team is always a point of contact if required for guidance.

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
					prompts to guide users in real time. Tutorial Resources: A detailed user manual and video tutorials are available through setup, scanning, and result interpretation. Ongoing Software Updates: Automatic updates to the substance library and scanning models via the cloud, ensuring the device stays accurate and current without any user intervention.		
Typical response time	Typical response time is same day contact and triage, 2 to 3 days to diagnose. No charge for initial contact and diagnosis. Onsite service or remote session usually have a charge. Return to factory	Business hours - Immediate. Off hours can vary from immediate to several minutes.	Business hours - Immediate. Off hours can vary from immediate to several minutes.	Same day to 2 days response	6 to 8 hours	< 24 hours on weekdays	< 72 hours is the goal for all service calls regardless of whether it is under warranty or outside of warranty. Priority will be given to a customer under a support contract for onsite repairs.

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
	service has a charge.						
Technical or user support included in the base purchase price?	Yes	Yes	Yes	Included in subscription.	Yes	Yes: basic support is included for the device lifetime and Reachback support is included for the first year.	Yes, the price includes 1 onsite training day with our local application scientist for instrument and software training. This is in addition what the service team will provide with the lab to set up and familiarize the lab staff with the hardware and software at installation.
Any additional cost associated with unique IT support (e.g., cybersecurity considerations)?	No	No	No	No	No	No	No
If not, what are the additional support-related fees?	Not provided or confidential	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not provided or confidential
Training and staffing							
Qualifications or training required to operate DCT	If a person can operate a Windows computer, they can be trained to operate our	Primarily safety training. Functionally, the quick start guide and on-screen	Primarily safety training. Functionally, the quick start guide and on-screen	None	No formal qualifications or prior technical training are required to operate	Basic proficiency in Windows software	The instrument user should have training and basic knowledge around FTIR, Spectral

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
	instruments. New Touch panel PC software is available making the operation even easier. Interpretation of data takes experience. New AI-driven software is available, potentially changing the experience requirements for those interpreting data.	prompts will enable a user to be functional in minutes, assuming all precautions are reviewed and considered.	prompts will enable a user to be functional in minutes, assuming all precautions are reviewed and considered.		the NIRLAB device. The system is specifically designed for ease of use in the field by nonspecialists. Scanning is initiated with a single button press, and results are delivered within seconds via the mobile app. NIRLAB provides a comprehensive user manual, tutorial videos, and onboarding support to ensure new users are fully comfortable with the workflow. Most users are able to operate the device confidently after a short introductory session.		interpretation and Sampling preparation and Optimization
Training costs	Introductory training is included in the purchase package. Follow-up training can be purchased as	Separate charge. “Can be” offered via video conference call at a reduced, or zero charge.	Separate charge. “Can be” offered via video conference call at a reduced, or zero charge.	Training is billed separately	Users have access to a comprehensive set of resources, including a user manual and	Virtual training included	Included

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
	remote sessions, courses, or in-person training courses. The British Columbia Centre on Substance Use (BCCSU) has extensive training and resource materials available for drug checking with Bruker ALPHA and MOBILE-IR II systems. Refer to https://drugcheckingbc.ca/ , for example. BCCSU also provides training sessions for new users and hosts meetings for drug checking personnel. Bruker offers on demand training and assistance on use of the hardware and software.				several step-by-step video tutorials. Additionally, online training can be provided upon request.		

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
Portability and infrastructure needs							
Physical space requirements for DCT	ALPHA II and MOBILE-IR II systems have the same footprint: about 21 × 32 cm (w x d). The computer to operate the system is typically an external notebook computer or Touch tablet like the MS Surface Pro 11.	Carrying case with all accessories measures approximately 25.4 cm x 22.9 cm x 15.25 cm	Carrying case with all accessories measures approximately 25.4 cm x 22.9 cm x 15.25 cm	30 cm x 30 cm x 30 cm	Size of a torch 19.4 cm x 4.7 cm, < 250 g	Device dimensions: 22.2 cm x 16.2 cm x 6.7 cm A small working desk space for the device and laptop is all that is needed.	W:62.6 cm x D:69.8 cm x H:27.6 cm
Portability and durability (e.g., can it be used outdoors)?	Both ALPHA II and MOBILE-IR II are portable. The ALPHA II needs to be kept dry. The MOBILE-IR II has a IP65 case so it dustproof and waterproof. Standard notebook or tablet computers need to be kept dry. A ruggedized tablet computer is available (e.g., like a Toughbook) if the environment requires it.	Very portable. Not susceptible to environmental changes.	Very portable. Not susceptible to environmental changes.	Portable; used in field, concerts, mobile vehicles.	Technology is housed in a robust, highly portable device designed specifically for field use. It features both IP65 and IP67 ratings, providing excellent resistance to dust and water, making it perfect for outdoor environments. The device is also built to withstand shock and vibration, ensuring durability in rugged	Yes, it can be used outdoors.	No

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
					conditions. Its sapphire glass screen is scratch-resistant, and the lamp inside offers an impressive lifespan of more than 40,000 hours. Additionally, the device boasts a 10-hour battery life, allowing for extended use without frequent recharging.		
Can DCT be used in a vehicle?	Yes, and also while moving (particularly the MOBILE-IR II).	Yes	Yes	Yes	Yes	Yes	No
If DCT can be used in a vehicle, what are the specific considerations for mobile deployment?	MOBILE-IR II is more rugged and recommended for mobile units. It has a built-in battery for up to 8 hours of operation.	None. Device is hand-held and intended for mobile use.	None. Device is hand-held and intended for mobile use.	Mobile hotspot	The only requirement is an internet connection to access the full library and have a full display of results. However, an offline mode exists that allows you to perform scans without internet access and then synchronize the data as soon as a connection is	Access to a Wi-Fi hotspot	Not applicable

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
					available, at which point the full results will be displayed.		
Compatibility							
Should DCT be used in combination with test strips?	We do recommend it because test strips are more sensitive, particularly for potent drugs that can be dangerous in less than 1% wt/wt levels. ALPHA II and MOBILE-IR II are very useful to provide a nonselective main composition, whereas test strips are generally very selective.	Ideally, yes	Ideally, yes	Yes	From a drug-checking perspective, NIR technology cannot detect substances that are added in very small amounts for adulteration. In such cases, NIRLAB recommends using test strips in addition, which can identify the presence of these small-quantity substances.	To increase confidence of detection results, any portable DCT method should be used in conjunction with other point-of-care methods when resources permit. Results of other methods can be logged on the Amplifi ID software.	No
If DCT should be used in combination with test strips, which ones?	Fentanyl and Xylazine Test Strips, e.g., BTNX	Various. We offer a wide variety.	Various. We offer a wide variety.	Fentanyl test strips	You could specifically consider test strips for fentanyl and synthetic opioids like nitazene, as well as for xylazine.	Benzodiazepines, Xylazine, and Medetomidine test strips on presumed street opioids/fentanyl samples if Trace Scan does not come back positive for these analytes.	Not applicable

DCT costs and capabilities	ALPHA, ALPHA II, and MOBILE-IR II FTIR (Bruker Ltd.) ^a	APEX R7 Raman (DETECTACHEM) ^b	SEEKER APEX Combo Kit (DETECTACHEM) ^b	Scatr Series One (Scatr Inc.) ^c	NIRLAB Device (NIRLAB) ^d	Amplifi ID™ Drug Analysis Spectrometer (Spectra Plasmonics Inc.) ^e	FTIR - Nicolet iS50 (Thermo Fisher Scientific Inc.) ^f
If DCT should be used in combination with test strips, are there added costs?	Test strips are purchased separately.	Yes. Most are CA\$33.78 per 10-count box. Some exceptions run CA\$54.10 per box	Yes. CA\$13.50 per 10-count box	Yes	Not reported	Not if they are available to the drug-checking service provider already through government programs. Spectra Plasmonics does not sell immunoassay test strips.	Not applicable
Company information							
Company website	https://www.bruker.com/en.html	https://detectachem.com/product-info/apex-r7-raman-spectrometer/	https://detectachem.com/product-info/apex-r7-pro-combo-kit/	https://scatr.ca/	https://www.nirlab.com/	https://www.spectraplasmonics.com/	https://www.thermofisher.com/order/catalog/product/912A0760
Company based in Canada	Yes	No	No	Yes	No	Yes	No. There is a location in Canada - Thermo Fisher Scientific (Mississauga) Inc.)

CA\$ = Canadian dollars; DCT = drug-checking technology; FTIR = Fourier Transform Infrared Spectroscopy; NIR = near-infrared.

^aPeter Krygsman, Ph.D. Regional Sales Manager, MIR, Raman Products, Bruker Ltd.: email communication, July 18, 2025

^bJeff DeBaker, Director of Sales, Detectachem: email communication, June 16, 2025

^cAri Forman, MSc, CEO, Scatr Inc.: email communication, August 11, 2025

^dMaurice Bleeker, Sales and Business Development Manager, NIRLAB SA: email communication, June 23, 2025

^eMalcolm Eade, BSc, Chief Executive Officer, Spectra Plasmonics Inc.: email communication, July 22, 2025

^fKatherine Walker, Ph.D., Product Manager, Life Science Mass Spectrometry, Thermo Fisher Scientific Inc.: email communication, July 25, 2025.

Table 35: Costs and Capabilities of Mass Spectrometry Drug-Checking Technologies

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
Type							
Drug-checking technique	Mass Spectrometry	Orbitrap High Res LC/MS system	High Res Orbitrap GC/MS system	Triple quadrupole GC/MS system	Triple quadrupole LC/MS system	Paper spray ion source mass spectrometry	Direct ionization Mass Spectrometry
Time required for DCT to provide results							
Time to results	< 3 minutes	5 to 20 minutes	5 to 20 minutes	5 to 20 minutes	5 to 20 minutes	5 minutes	1 minute
Pricing and fees							
Total purchase price of DCT (CA\$)	Not provided or confidential	CA\$700,000	Not provided or confidential	Not provided or confidential	Not provided or confidential	Not provided or confidential	Not provided or confidential
Inclusions in the purchase price	Not provided or confidential	Software updates or database/library upgrades. Perpetual licence. Online support. Shipping, installation, and familiarization. One year warranty	Software updates or database/library upgrades. Perpetual licence. Online support. Shipping, installation, and familiarization. Full GC/MS system with 1 year warranty and consumables voucher	Software updates or database/library upgrades. Perpetual licence. Online support. Shipping, installation and familiarization. Full GC/MS system with 1 year warranty and consumables voucher	Software updates or database/library upgrades. Perpetual licence. Online support. Shipping, installation, and familiarization. Full GC/MS system with 1 year warranty and consumables voucher	Not provided or confidential	Software updates or database/library upgrades. Online support. Installation, Onsite training and 5 years of bumper-to-bumper warranty coverage with annual preventive maintenance
Ongoing operational costs (e.g., consumables,	Not provided or confidential	Software upgrades ~CA\$5,000 (optional). Depending on	Software upgrades ~CA\$5,000 (optional). Depending on	Software upgrades ~CA\$5,000 (optional). Depending on	Software upgrades ~CA\$5,000 (optional). Depending on	Not provided or confidential	100 pack Glass Capillaries at CA\$150, No

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
reagents, test cartridges, maintenance)?		sample volume, budget should be between CA\$3,000 to 4,000/year	sample volume, budget should be between CA\$3,000 to 4,000/year	sample volume, budget should be between CA\$3,000 to 4,000/year	sample volume, budget should be between CA\$3,000 to 4,000/year		maintenance costs for 5 years.
Subscription or licensing fees	Not provided or confidential	No	No	No	No	Not provided or confidential	No
Pricing for bulk purchases or for community-based organizations	Not provided or confidential	Yes	Yes	Yes	Yes	Not provided or confidential	Yes
Financing option	Not provided or confidential	Yes	Yes	Yes	Yes	Yes	Yes
Leasing option	Not provided or confidential	Yes	Yes	Yes	Yes	Yes	Yes
Rental option	Not provided or confidential	No	No	No	No	Yes	Yes
Warranty	Not provided or confidential	Yes: The instrument comes with 1 year factory which is included on all the hardware (Triple Quadrupole and LC system). Includes unlimited engineer labour, travel and factory-certified replacement parts required for corrective	Yes: The instrument comes with 1 year factory which is included on all the hardware. Includes unlimited engineer labour, travel and factory-certified replacement parts required for corrective maintenance. Priority unlimited	Yes: The instrument comes with 1 year factory warranty which is included on all the hardware: Includes unlimited engineer labour, travel and factory-certified replacement parts required for corrective maintenance; Priority unlimited	Yes: The instrument comes with 1 year factory warranty which is included on all the hardware (Triple Quadrupole and LC system). Triple Quadrupole comes with, i.e., included in the price, 3 year basic warranty at purchase. Good for a period	Yes: The instrument comes with 1 year factory warranty which is included on all the hardware (Triple Quadrupole and VeriSpray front end). Triple Quadrupole comes with — that is, included in the price previously indicated, 3 year	5 years of bumper-to-bumper coverage is included in system price (cost of warranty not provided or confidential)

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
		maintenance. Priority unlimited access to trained technical support experts who can diagnose, investigate, and remotely resolve issues or schedule onsite visits using the latest digital remote support tools; Access to online service knowledgebase; Instrument Software/ Firmware updates included as needed to support a corrective maintenance visit.	access to trained technical support experts who can diagnose, investigate, and remotely resolve issues or schedule onsite visits using the latest digital remote support tools; Access to online service knowledgebase; Instrument Software/ Firmware updates included as needed to support a corrective maintenance visit.	access to trained technical support experts who can diagnose, investigate, and remotely resolve issues or schedule onsite visits using the latest digital remote support tools; Access to online service knowledgebase; Instrument Software/ Firmware updates included as needed to support a corrective maintenance visit.	of 12 months (from installation or from purchase order date if purchased separately): Includes unlimited engineer labour, travel and factory-certified replacement parts required for corrective maintenance; Priority unlimited access to trained technical support experts who can diagnose, investigate, and remotely resolve issues or schedule onsite visits using the latest digital remote support tools; Access to online service knowledge base; Instrument Software/Firmware updates included as needed to support a corrective maintenance visit.	basic warranty at purchase. Good for a period of 12 months (from installation or from purchase order's date if purchased separately): Includes unlimited engineer labour, travel and factory-certified replacement parts required for corrective maintenance; Priority unlimited access to trained technical support experts who can diagnose, investigate, and remotely resolve issues or schedule onsite visits using the latest digital remote support tools; Access to online service knowledgebase; Instrument Software/Firmware updates included	

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/ VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
						as needed to support a corrective maintenance visit.	
Servicing and support							
Servicing DCT	Remote and onsite	Remote support if required, available 5 days a week from 8:00 to 5:00 p.m. EST using the 1-800 number. Onsite support through a ticket or call to service help desk with s certified service engineer.	Remote support if required, available 5 days a week from 8:00 to 5:00 p.m. EST using the 1-800 number. Onsite support through a ticket or call to service help desk with s certified service engineer.	Remote support if required, available 5 days a week from 8:00 to 5:00 p.m. EST using the 1-800 number. Onsite support through a ticket or call to service help desk with s certified service engineer.	Remote support if required, available 5 days a week from 8:00 to 5:00 p.m. EST using the 1-800 number. Onsite support through a ticket or call to service help desk with s certified service engineer.	Remote support if required, available 5 days a week from 8:00 to 5:00 p.m. EST using the 1-800 number. Onsite support through a ticket or call to service help desk with s certified service engineer.	Factory-certified field service group in Canada.
Expected service and maintenance costs	Warranty or quotation based on travel, labour hours and parts	All costs included while service contract is valid	All costs included while service contract is valid	All costs included while service contract is valid	All costs included while service contract is valid	Not reported	5 years of bumper-to-bumper coverage is included in system price (cost of warranty not provided or confidential).
Unique IT considerations applicable to DCT (e.g., cybersecurity)	Currently do not support unique IT requirements, details need to be further discussed.	None	None	None	None	None	None

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
Access to DCT support	48 hours response under warranty	Offer e-learning, a 1-800 number for service-related questions, an application chemist can be contacted by email or provide remote support on the application, cloud for service software for entering service tickets for onsite support, the sales team is always a point of contact if required for guidance.	Offer e-learning, a 1-800 number for service-related questions, an application chemist can be contacted by email or provide remote support on the application, cloud for service software for entering service tickets for onsite support, the sales team is always a point of contact if required for guidance.	Offer e-learning, a 1-800 number for service-related questions, an application chemist can be contacted by email or provide remote support on the application, cloud for service software for entering service tickets for onsite support, the sales team is always a point of contact if required for guidance.	Offer e-learning, a 1-800 number for service-related questions, an application chemist can be contacted by email or provide remote support on the application, cloud for service software for entering service tickets for onsite support, the sales team is always a point of contact if required for guidance.	Offer e-learning, a 1-800 number for service-related questions, an application chemist can be contacted by email or provide remote support on the application, cloud for service software for entering service tickets for onsite support, the sales team is always a point of contact if required for guidance.	1-800 toll-free service line or service/support may be requested via web-based iRequest service.
Typical response time	48 hours	< 72 hours is the goal for all service calls, regardless of whether it is under warranty or outside of warranty. Priority will be given to a customer under a support contract for onsite repairs.	< 72 hours is the goal for all service calls, regardless of whether it is under warranty or outside of warranty. Priority will be given to a customer under a support contract for onsite repairs.	< 72 hours is the goal for all service calls, regardless of whether it is under warranty or outside of warranty. Priority will be given to a customer under a support contract for onsite repairs.	< 72 hours is the goal for all service calls, regardless of whether it is under warranty or outside of warranty. Priority will be given to a customer under a support contract for onsite repairs.	< 72 hours is the goal for all service calls, regardless of whether under warranty or outside of warranty. Priority will be given to a customer under a support contract for onsite repairs.	within 4 hours of iRequest being made.
Technical or user support included in the base purchase price?	One-year warranty included	The price includes 3 onsite training days with local application scientist	The price includes 3 onsite training days with local application scientist	The price includes 3 onsite training days with local application scientist	The price includes 3 onsite training days with local application scientist	The price includes 3 onsite training days with local application scientist	Yes

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
		for instrument and software training. This is in addition to what the service team will provide the lab to set up and familiarize the lab staff with the hardware and software at installation.	for instrument and software training. This is in addition to what the service team will provide the lab to set up and familiarize the lab staff with the hardware and software at installation.	for instrument and software training. This is in addition to what the service team will provide the lab to set up and familiarize the lab staff with the hardware and software at installation.	for instrument and software training. This is in addition to what the service team will provide the lab to set up and familiarize the lab staff with the hardware and software at installation.	for instrument and software training. This is in addition to what the service team will provide the lab to set up and familiarize the lab staff with the hardware and software at installation.	
Any additional cost associated with unique IT support (e.g., cybersecurity considerations)?	Do not have unique IT support	No	No	No	No	No	No, Waters use Team Viewer for remote support
If not, what are the additional support-related fees?	Not applicable	If more onsite training is required, additional training can be purchased (e.g., CA\$5,400 for 3 days at government cost)	If more onsite training is required, additional training can be purchased (e.g., CA\$5,400 for 3 days at government cost)	If more onsite training is required, additional training can be purchased (e.g., CA\$5,400 for 3 days at government cost)	If more onsite training is required, additional training can be purchased (e.g., CA\$5,400 for 3 days at government cost)	If more onsite training is required, additional training can be purchased (e.g., CA\$5,400 for 3 days at government cost)	Not applicable
Training and staffing							
Qualifications or training required to operate DCT	No qualification required for routine use, LC-MS background for method development	The instrument user should have training and knowledge around running analytical instrumentation	The instrument user should have training and knowledge around running analytical instrumentation	The instrument user should have training and knowledge around running analytical instrumentation	The instrument user should have training and knowledge around running analytical instrumentation	The instrument user should have training and knowledge around running analytical instrumentation	Limited knowledge needed to run the system, simple plug-and-play software once the standard method is

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
		(mass spectrometry is preferred, related to either GC or LC)	(mass spectrometry is preferred, related to either GC or LC).	(mass spectrometry is preferred, related to either GC or LC).	(mass spectrometry is preferred, related to either GC or LC).	(mass spectrometry is preferred, related to either GC or LC).	set up in the initial training.
Training costs	Included	The price includes 3 onsite training days with local application scientist for instrument and software training. This is in addition to what the service team will provide with the lab to set up and familiarize the lab staff with the hardware and software at installation.	The price includes 3 onsite training days with local application scientist for instrument and software training. This is in addition to what the service team will provide with the lab to set up and familiarize the lab staff with the hardware and software at installation.	The price includes 3 onsite training days with local application scientist for instrument and software training. This is in addition to what the service team will provide with the lab to set up and familiarize the lab staff with the hardware and software at installation.	The price includes 3 onsite training days with local application scientist for instrument and software training. This is in addition to what the service team will provide with the lab to set up and familiarize the lab staff with the hardware and software at installation.	The price includes 3 onsite training days with local application scientist for instrument and software training. This is in addition to what the service team will provide with the lab to set up and familiarize the lab staff with the hardware and software at installation.	Included in the purchase.
Portability and infrastructure needs							
Physical space requirements for DCT	35 cm x 25 cm x 15 cm	Depth: 152.4 cm Width: 114.3 cm Height: 101.6 cm	Depth: 101.6 cm Width: 137.16 cm Height: 81.28 cm	Depth: 88.9 cm Width: 137.16 cm Height: 81.28 cm	Depth: 88.9 cm Width: 106.68 cm Height: 81.28 cm	Width: 66 cm Height: 70 cm Depth: 81 cm Weight: 131 kg Data system to be used on a workbench that can hold the mini-tower computer, wide-screen monitor,	Instrument size is maximum of 84.6 cm x 34.3 cm x 27.2 cm

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
						keyboard, Ethernet switch, and optional laser printer.	
Portability and durability (e.g., can it be used outdoors)?	Yes, it can be used outdoors, the battery can last 2 hours	No	No	No	No	No	No, cannot be used outdoors
Can DCT be used in a vehicle?	Yes	No	No	No	No	No	Yes
If DCT can be used in a vehicle, what are the specific considerations for mobile deployment?	No specific considerations	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Need to have a nitrogen generator and 120 V power supply for the instrument. Instrument should be turned off while vehicle is in motion. Should meet the site requirements document
Compatibility							
Should DCT be used in combination with test strips?	No, the instrument use PURSPEC's own cartridge	No	No	No	No	No	Not applicable
If DCT should be used in combination with test strips, which ones?	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

DCT costs and capabilities	Mini MS (PURSPEC Technologies Inc.) ^a	Exploris 120 with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	Exploris GC (60k MSMS or 240 depending on application) (Thermo Fisher Scientific Inc.) ^b	TSQ 9610 (Thermo Fisher Scientific Inc.) ^b	TSQ Quantis Plus with Vanquish Flex UHPLC (Thermo Fisher Scientific Inc.) ^b	TSQ Series II MS/VeriSpray (Thermo Fisher Scientific Inc.) ^b	RADIAN ASAP (Waters Corporation) ^c
If DCT should be used in combination with test strips, are there added costs?	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Company information							
Company website	https://www.purspec.com/	https://www.thermofisher.com/ca/en/home/industrial/chromatography/liquid-chromatography-lc/hplc-uhplc-systems/vanquish-flex-uhplc-system.html	https://www.thermofisher.com/ca/en/home/industrial/mass-spectrometry/gas-chromatography-mass-spectrometry-gc-ms/gc-ms-systems/high-resolution-accurate-mass-gc-ms/orbitrap-exploris-gc.html	https://www.thermofisher.com/order/catalog/product/TSQ9610-NV-AEI	https://www.thermofisher.com/ca/en/home/industrial/chromatography/liquid-chromatography-lc/hplc-uhplc-systems/vanquish-flex-uhplc-system.html	https://www.thermofisher.com/ca/en/home/industrial/mass-spectrometry/liquid-chromatography-mass-spectrometry-lc-ms/lc-ms-accessories/verispray-paperspray-ion-source-mass-spectrometry.html	https://www.waters.com/nextgen/ca/en.html
Company based in Canada	No	No. There is a location in Canada - Thermo Fisher Scientific (Mississauga) Inc.)	No. There is a location in Canada - Thermo Fisher Scientific (Mississauga) Inc.)	No. There is a location in Canada - Thermo Fisher Scientific (Mississauga) Inc.)	No. There is a location in Canada - Thermo Fisher Scientific (Mississauga) Inc.)	No. There is a location in Canada - Thermo Fisher Scientific (Mississauga) Inc.)	No. There is a location in Canada – Waters Limited (Mississauga)

DCT = drug-checking technology; GS = gas chromatography; LC = liquid chromatography; MS = mass spectrometry; TSQ = triple stage quadrupole.

^aJiexun Bu, PhD, Chief Scientist and Deputy Director, Creative Design Center, PURSPEC Technologies Inc. and PURSPEC Technology (China) Ltd.: email communication, July 9, 2025

^bKatherine Walker, Ph.D., Product Manager, Life Science Mass Spectrometry, Thermo Fisher Scientific Inc.: email communication, July 25, 2025.

^cRachel Lieberman, Ph.D., Global Forensic and Toxicology Marketing Manager, Waters Corporation: email communication, July 21, 2025



Canada's Drug Agency
L'Agence des médicaments du Canada
Drugs. Health Technologies and Systems. Médicaments, technologies de la santé et systèmes.

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