Research Paper

Acceptability of implementing community-based drug checking services for people who use drugs in three United States cities: Baltimore, Boston and Providence

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ABSTRACT

Background: North America is experiencing a rising trend of opioid overdose exacerbated primarily in recent years through adulteration of the heroin supply with fentanyl and its analogues. The east coast of the United States has been particularly hard hit by the epidemic. In three east coast states of Maryland, Massachusetts and Rhode Island, fentanyl has been detected in over half of all overdoses with available toxicology screens. To determine the acceptability of drug checking involving fentanyl test strips (FTS) or other technologies among those at high risk for overdose, we assessed correlates of intention to utilize such services and logistical preferences among people who use drugs (PWUD).
Methods: Through FORECAST (the Fentanyl Overdose REduction Checking Analysis STudy), street-based PWUD (N = 334) were recruited in Baltimore, Maryland, Boston, Massachusetts, and Providence, Rhode Island. Questionnaires 7were administered from June to October 2017 and ascertained drug use, overdose history, fentanyl knowledge, and drug checking intent and logistical preferences. Pearson's χ^2 and logistic regression determined factors associated with drug checking intent.
Results: Overall, 84% were concerned about fentanyl, 63% had ever overdosed, and 42% had ever witnessed a fatal overdose. Ninety percent felt drug checking would help them prevent an overdose, the majority of those interested would utilize drug checking at least daily (54%). Factors independently associated with intent to use drug checking included: older age (aOR: 1.5, 95% CI: 1.3–1.8); homelessness (aOR: 0.6, 95% CI: 0.5–0.7); being non-white (aOR: 2.0, 95% CI: 1.0–4.0); witnessing ≥1 fatal overdose (aOR: 1.6, 95% CI:1.1–2.3); and suspected recent fentanyl exposure (aOR: 1.8, 95% CI: 1.1–3.1).
Conclusions: The majority of PWUD endorsed drug checking for overdose prevention, with intent amplified by having witnessed a fatal overdose and recent fentanyl exposure. Drug checking should be part of a comprehensive approach to address the risks associated with the proliferation of fentanyl.

Introduction

Fatal drug-related overdoses claimed 72,855 lives in the 12-month period ending November 2017 in the United States, a 13% increase over the previous 12-month period (Ahmad, Rossen, Spencer, Warner, & Sutton, 2018). Deaths due to drug overdose have been a burgeoning problem, and resulted in an increase in the overall US mortality rate in 2015 for the first time in over 15 years (Xu, Murphy, Kochanek, & Arias,

2016). This increase was largely driven by opioid overdose mortality, an outcome of several converging factors: increased number of susceptible people owing to the proliferation of pharmaceutical opioids; an expanded and cheaper heroin market; and the rise of adulterated illicit drug markets, such as the heroin market, with synthetic opioids, primarily illicitly manufactured fentanyl and its analogues (Ciccarone, 2017). While the U.S. continues to have the highest drug-related mortality rate in the world, opioid overdose deaths are also climbing in

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Canada, the United Kingdom, Australia, and several countries in Eastern and Western Europe (Harm Reduction International, 2016). The magnitude of this steep increase has created an extremely risky environment for overdose deaths for people who use drugs (PWUD).

Deaths in the U.S. from synthetic opioids other than methadone climbed from 3,105 in 2013 to 20,145 in 2016 (Centers for Disease Control, 2018). Fentanyl, a synthetic opioid that in its pure form is approximately 50–100 times more potent than morphine (Drug Enforcement Administration, 2016), is used clinically for anesthesia and pain management. Illicit use of pharmaceutical fentanyl has been documented in the U.S. (Kuczyńska, Grzonkowski, Kacprzak, & Zawilska, 2018), but is not the primary driver of fentanyl-related mortality as it is in some countries such as Australia (Roxburgh et al., 2013). Fentanyl can be synthesized cheaply and covertly in underground laboratories. After production, fentanyl enters the illicit drug supply primarily as an adulterant to heroin (DEA Strategic Intelligence Section, 2015), but also packaged in counterfeit opioid medication tablets (Arens et al., 2016; Drug Enforcement Administration: Strategic Intelligence Section, 2016), and mixed with stimulants such as cocaine (Marinetti & Ehlers, 2014). The fentanyl epidemic includes the chemical itself and at least 15 analogues identified thus far by the U.S. Drug Enforcement Agency as involved in current outbreaks (O'Donnell, Halpin, Mattson, Goldberger, & Matthew, 2017); seizures of fentanyl family chemicals increased fourteen fold between 2013 and 2015 (Drug Enforcement & Administration, 2015).

The presence, dose, and type of fentanyl in street heroin, illicitly manufactured opioid pills, and other drugs is largely unknown to consumers, placing individuals at high risk of accidental overdose (Amlani et al., 2015; Ciccarone, Ondocsin, & Mars, 2017). The U.S. east coast has been heavily impacted, where heroin's white powder form is easily adulterated by fentanyl and fentanyl analogues (DEA Strategic Intelligence Section, 2015). For example, in Baltimore City, Maryland, fentanyl-related overdose deaths increased 249% from 2015 to 2016 (Maryland Department of Health & Mental Hygiene, 2017). Fentanyl was detected in over half of overdose deaths in Rhode Island in 2016 (Marshall et al., 2017), and in more than three quarters of opioid-related deaths in Massachusetts (Massachusetts Department of Public Health, 2016).

Drug checking

Drug checking services enable PWUD to chemically analyze their drugs for the presence of substances like fentanyl and other adulterants, allowing them to make more informed decisions about subsequent use (Harper, Powell, & Pijl, 2017). Drug checking also provides an opportunity for engagement with PWUD and the provision of counseling, harm reduction education, and referrals to services (e.g., substance use disorder treatment) as well as the opportunity to monitor the presence of dangerous drugs on the drug market at the municipal level (Glick et al., 2019). Drug checking was pioneered in Europe and has the potential to promote product safety into the illicit drug supply in the U.S., where its use has been limited to testing the purity of empathogenic drugs and cocaine, primarily on-site at dance festivals (Bardwell & Kerr, 2018; Brunt et al., 2017). Several technologies have been employed in checking drugs for fentanyl. Rapid response fentanyl test trips (FTS) detect the presence of fentanyl and some of its analogues via chromatographic immunoassay, and have recently been distributed by syringe services programs (SSPs) and safe injection facilities for off-label use in North America (Kennedy et al., 2018; Lysyshyn, Dohoo, Frosting, Kerr, & McNeil, 2017). Benefits of FTS include low cost and the capability for checking by consumers directly before drug use. A second technology is a desktop-size spectrometer utilizing Fourier Transform Infrared technology (FTIR), which provides information about the full array and relative amounts of drugs in a given sample and helps to develop a local library of illicit substances. However, they are limited by intensive staff training, an environment where PWUD are comfortable bringing their

drugs, and expense (˜$20,000-25,000 USD) (Barratt, Kowalski, Maier, & Ritter, 2018; Brunt & Niesink, 2011). In the first study examining the results of a pilot drug checking program that included both the use of FTS and an FTIR in Vancouver, Canada at the safe injection facility Insite, 90.6% of samples expected to be heroin tested positive for fentanyl by the FTS (Tupper, McCrae, Garber, Lysyshyn, & Wood, 2018).

Several studies have explored and validated drug checking willingness. Feasibility and acceptability studies among PWUD are demonstrated valid predictors of future behavior in the context of SIF utilization (Debeck et al., 2012). In the city of London in Ontario, Canada, 43% of who injected drugs (PWID) expressed willingness for onsite drug checking at a proposed supervised injection facility (Kennedy et al., 2018). A Rhode Island study of young PWID found that 92% of participants wanted to know if there was fentanyl in their drug supply and would check their drugs for fentanyl (Krieger et al., 2018). A recent study in Greensboro, North Carolina found much higher rates of FTS utilization prior to consumption (81%) among people who inject opioids, and that a fentanyl-positive test result was significantly associated with a change in drug use behavior (Peiper et al., 2018). Yet gaps in this small body of literature remain. There are limited data on the feasibility and acceptability of drug checking methods as well as related logistical preferences among PWUD. Additionally, the small body of recent literature primarily focuses on people who inject opioids, excluding non-injectors at risk given the lethality of the drug market.

We explored feasibility, acceptability, and perceived behavioral outcomes of drug checking among a multicity population of PWUD (N = 334) in the FORECAST (Fentanyl Overdose REduction Checking Analysis STudy) (Glick et al., 2019). PWUD were surveyed in three U.S. east coast cities burdened with high rates of fatal overdoses - Baltimore, Maryland, Providence Rhode Island, and Boston.

Methods

Data collection occurred from June to October 2017 during a period where FTS were not being provided by city agencies or other harm reduction organizations in Baltimore City or Providence but were at one location in Boston. Recruitment occurred through targeted sampling in Baltimore at eight locations and through convenience sampling in both Boston at a single site and Providence at three sites. In Baltimore, publicly accessible Baltimore City Police Department 2016 drug arrest data were mapped to determine geographic and temporal concentrations of drug activity for targeted recruitment. The study team systematically recruited the sample (n = 175) on a research van during the periods determined by spatiotemporal mapping. Recruitment occurred within a 2-block radius of the study vehicle. In Boston, participants (n = 80) were recruited by study staff from an SSP primarily during peak hours of operation. In Providence, participants (n = 79) were recruited at an SSP covering all hours of operation at least once and during street outreach conducted by two harm reduction programs.

In all three cities, individuals' interest in participating in an anonymous health study was ascertained. Those who accepted were screened for the eligibility criteria: having used non-medical heroin, fentanyl, street-opioid pills, cocaine or methamphetamines, or used opioid medications not as prescribed in the past 30 days; being 18 years or older; and ability to speak English. Informed consent was provided orally. Eligible participants completed an anonymous, 30-minute, computer-assisted personal interview survey that was administered by a study interviewer. Interviewers across the three sites were trained in a single training by the study's third author at the onset of the study. Each location had interviewers who were experienced with research among the target population and some of whom have experience with illicit street-based drug use. Participants were compensated with a pre-paid $25 VISA card in Baltimore or $25 cash in Boston and Providence.

Of 406 participants screened across all three study sites, 340 (84%) were eligible for participation, 337 (99%) of whom agreed to participate. Two participants did not complete the survey and one was

Table 1

Sociodemographic characteristics of people who use drugs: Baltimore, Boston, and Providence, USA, 2017.

Characteristic	Baltimore		Boston		Providence		Total	
	N = 175		N = 80		N = 79		N = 334	
	No.	%	No.	%	No.	%	No.	%
Age – Median (IQR)	45	(35–53)	40	(34–49)	43	(34–49)	42	(34–51)
Gender								
Male	97	55.4	51	64.6	47	59.5	195	58.6
Female	78	44.6	28	35.4	32	40.5	138	41.4
Racial Category ***								
White	44	25.1	58	72.5	53	67.1	155	46.4
Black	111	63.4	9	11.3	14	17.7	134	40.1
Other	6	3.4	3	3.8	5	6.3	14	4.2
Multiracial	14	8.0	10	12.5	7	8.9	31	9.3
Ethnicity								
Hispanic ***	2	1.1	22	27.5	15	19.0	39	11.7
Highest level of education completed								
Some high school	73	41.7	25	31.3	28	35.4	126	37.7
High school diploma / GED	66	37.7	38	47.5	35	44.3	139	41.6
Some college / college degree	36	20.6	17	21.3	16	20.3	69	20.7
Homeless, currently ***	105	60.0	69	86.3	53	67.1	227	68.0
Main sources of income, last 3 months								
Full or part-time work *	23	13.1	6	7.5	18	22.8	47	14.1
Drug trade ***	33	18.9	35	43.8	27	34.2	95	28.4
Arrested / incarcerated, last year ***	58	33.1	55	68.8	40	50.6	153	45.8

Significance (Chi2 p-values): * - p < 0.05, ** p < 0.01, *** p < 0.001.

excluded due to their only opioid use being prescribed pharmaceutical methadone, leaving 334 in the final analysis. The study was approved by the Johns Hopkins Bloomberg School of Public Health and the Rhode Island Hospital Institutional Review Boards.

The survey ascertained socio-demographic characteristics (age dichotomized around 35 years, gender, race/ethnicity, education, homeless status), recency (past 6 months) and frequency of drug use, routes of drug administration, ever and past year overdose (experiencing and witnessing), and knowledge of, concern about, and experiences with fentanyl. Due to small sample sizes for Hispanic ethnicity and race outside of white and black, race and ethnicity were collapsed as non-Hispanic white or other (including multiracial).

Fentanyl items were modified from previous studies in Baltimore (Park, Weir, Allen, Chaulk, & Sherman, 2018) and Rhode Island (Carroll, Marshall, Rich, & Green, 2017). Drug checking for fentanyl was defined as a method where "a small amount of your drugs would be checked to see if it contains fentanyl." Three separate techniques were described to participants: one technique involved a machine like the FTIR that detects the contents and quantity of drugs and cutting agents in a small sample analyzed by a staff member; the other two techniques involved the aforementioned rapid response FTS, one with on-site testing by a staff member and the other receiving the strips to take with them. Once described, intent to utilize drug checking was measured with "how interested would you be in checking your drugs for fentanyl?" with a 4-point Likert scale. Responses were dichotomized as "high interest" ("interested" and "very interested") and "low or no interest" ("not interested at all" and "somewhat interested"). Interested participants were then asked questions relating to their logistical preferences and utilization of drug checking, such as the amount of their drugs they would be willing to provide for analysis, type of information the analysis would provide (presence of fentanyl, amount of fentanyl in a sample, presence of additional adulterants, etc.), frequency of utilization, locations within their city they would hope to access such services, etc.

Suspected fentanyl exposure was assessed by asking "have you ever used a drug that you thought had fentanyl in it?" and then ascertaining recency. Fentanyl preference was assessed through endorsement of "I prefer drugs that have fentanyl in them" and measured on a four-point Likert scale (strongly disagree, somewhat disagree, somewhat agree,

strongly agree), with both "agree" categories considered a fentanyl preference. Ability to detect fentanyl adulteration by observation was constructed through agreement that "drugs that have fentanyl in them taste/smell/look differently than drugs without fentanyl," asked as three separate questions.

To ascertain differences between cities, participants within each city were compared using Pearson's chi-square test to explore differences by city of recruitment and by dichotomized drug checking interest groups. The sub-set of correlates significant at the p < 0.20 level were reported, and these, along with theoretically relevant variables, were considered for inclusion in multivariate modeling. Bivariate Wald's t-tests were performed for candidate continuous variables and the drug checking outcome of interest. Logistic regression, with robust standard errors clustered by the three recruitment cities, was utilized to determine which variables had the greatest associations with drug checking intent. The primary outcome was intent to utilize drug checking services. Independent variables of interest included recent use of a drug suspected of containing fentanyl, preference for fentanyl, having ever witnessed a fatal overdose, and believing that drugs containing fentanyl look, taste or smell differently than unadulterated drugs. Other covariates controlled for in analysis included age, race/ethnicity, and homelessness. Pairwise Spearman's correlations were examined to ensure potential covariates were not overly associated prior to inclusion in regression; absolute values of the final model variables' correlation coefficients were < 0.30. All analyses were conducted in Stata/SE 14.2 (StataCorp, 2015).

Results

Participant characteristics are located in Table 1, stratified by city. Across cities, median age was 42 years, 59% were male, and 42% completed high school or their GED. Demographics differed by city. Participants in Baltimore were 63% Black, 25% white, and 1% Hispanic; Boston was 73% white, 11% Black, and 28% Hispanic; Providence was 67% white, 18% Black, and 19% Hispanic (p < 0.001). There were significant differences (p < 0.05) by city in reports of current homelessness, having full or part-time licit employment, working in the drug trade, and having been arrested in the past year.

Drug use patterns and overdose history among participants are

Table 2

Drug use and overdose history among people who use drugs: Baltimore, Boston, and Providence, USA, 2017.

Characteristic	Baltimore		Boston		Providence		Total	
	N = 175		N = 80		N = 79		N = 334	
	No.	%	No.	%	No.	%	No.	%
Recent drug use †								
≥ 2 types of illicit drugs **	156	89.1	80	100.0	68	86.1	304	91.0
Heroin *	143	81.7	76	95.0	65	82.3	284	85.0
Snorted or smoked ***	94	65.7	19	25.0	29	44.6	142	50.0
Injected	82	57.3	72	94.7	55	84.6	209	73.6
Daily heroin	100	57.1	45	56.3	35	44.3	180	53.9
Crack cocaine, smoked	133	76.0	57	71.3	52	65.8	242	72.5
Daily crack cocaine, smoked **	61	34.9	14	17.5	18	22.8	93	27.8
Powdered cocaine **	74	42.3	51	63.7	45	57.0	170	50.9
Snorted ***	42	56.8	11	21.6	32	71.1	85	50.0
Injected ***	46	62.2	48	94.1	23	51.1	117	68.8
Daily powdered cocaine	29	16.6	12	15.0	6	7.6	47	14.1
Injection drugs ***	94	53.7	75	93.8	57	72.2	226	67.7
Daily injection drugs	69	39.4	43	53.8	38	48.1	150	44.9
Speedball injection ***	63	36.0	54	67.5	21	26.6	138	41.3
Daily speedball injection *	33	18.9	14	17.5	4	5.1	51	15.3
Methamphetamine use ***	8	4.6	27	33.8	8	10.1	43	12.9
Prescribed pharmaceutical opioids **	77	44.0	52	65.0	43	54.4	172	51.5
Prescribed pharmaceutical tranquilizer / benzodiazepine ***	20	11.4	27	33.8	25	31.6	72	21.6
Non-prescribed pharmaceutical opioid use	83	47.4	37	46.3	33	41.8	153	45.8
Non-prescribed pharmaceutical tranquilizer / benzodiazepine use ***	59	33.7	52	65.0	36	45.6	147	44.0
Fentanyl								
Concerned about drugs having fentanyl	142	81.6	72	90.0	65	83.3	279	84.0
Thinks drugs with fentanyl look, smell, or taste differently	138	78.9	61	76.3	56	70.9	255	76.3
Recent use of drugs thought had fentanyl † ***	128	73.1	70	87.5	45	57.0	243	72.8
Wanted to know drug had fentanyl before last use ‡	119	87.5	57	78.1	40	85.1	216	84.4
Prefer drugs with fentanyl *	52	29.7	22	27.5	11	13.9	85	25.4
Overdose								
Opioid overdose, ever ***	95	54.6	67	83.8	48	60.8	210	63.1
Opioid overdose, last year ***	66	37.7	50	62.5	27	34.2	143	42.8
1–2	42	63.6	24	48.0	15	55.6	81	56.6
≥ 3	24	36.4	26	52.0	12	44.4	62	43.4
Suspected overdose due to fentanyl *	61	92.4	45	90.0	20	74.1	126	88.1
Witnessed fatal overdose, ever	72	41.1	39	48.8	24	30.4	135	40.4
Called 911 last time witnessed overdose §	121	81.2	62	80.5	50	75.8	233	79.8
Have naloxone currently ***	61	34.9	57	71.3	40	50.6	158	47.3

Significance (Chi2 p-values): * - p < 0.05, ** p < 0.01, *** p < 0.001.

† Recent use is defined as the last 6 months.

‡ Among those whose drugs had ever had fentanyl (Baltimore n = 136, Boston n = 73, Providence n = 47, Total n = 256).

§ Among those who had ever witnessed an overdose (Baltimore n = 150, Boston n = 77, Providence n = 66, Total n = 293).

located in Table 2, stratified by city. Almost all (91%) reported recent use of multiple illicit drugs. Across cities, daily drug use included heroin (54%) and powdered cocaine (14%), as well as daily injection drug use (45%). There were significant differences (p < 0.05) by city in recent use of: heroin by any route and by smoking or snorting; daily smoking of crack cocaine; powdered cocaine by any route and by snorting and injecting; injection drug use, speedball (i.e., heroin/cocaine) injection; methamphetamine; and non-prescription use of pharmaceutical tranquilizers and benzodiazepines. Reported use of non-prescribed pharmaceutical opioids differed significantly by city (p < 0.01), with 46% of all participants reporting use of non-prescribed pharmaceutical opioids. When asked about the first type of opioid ever used, 34% reported heroin, 24% reported prescribed pharmaceutical opioids, 18% reported using non-prescribed pharmaceutical opioids, and 22% reported multiple substances as part of their initiation. Only 2% of the sample had never used an opioid [data not shown].

The majority of respondents were concerned about fentanyl adulteration in their drugs (84%), with significant differences (p < 0.001) by city in reported recent use of a drug containing fentanyl. Seventy-six percent of participants thought that they were able to detect fentanyl through appearance, smell, or taste; of those, 86% wished that they had known their drugs contained fentanyl prior to their last consumption.

There were significant differences by city regarding preference for using fentanyl-adulterated drugs (p < 0.05).

Ever having experienced an opioid overdose was common, though differed by city (p < 0.001). 43% of respondents overdosed in the past year, 57% of whom overdosed 1–2 times and 43% three or more times; most (88%) attributed their last overdose to fentanyl in their drugs. Across cities, 40% had ever witnessed a fatal overdose. Eighty percent reported having called 911 after their last witnessed overdose, with significant differences (p < 0.001) by city in naloxone possession.

Table 3 summarizes participants' drug checking interest and associated logistical preferences by city. Interest in drug checking was high, with 85% expressing any interest and the great majority reporting a belief that drug checking would help protect them from overdose (90%), though this differed by city (p < 0.05). Most participants (70%) reported that they would change their usage behavior if they knew their drug had fentanyl; when asked how, the three most common responses were: not using/throwing away the drug; ceasing purchase of drugs from the specific dealer; and using less. There were significant differences by city in the percentage of participants who reported that they would ask the person selling drugs to check the supply (p < 0.001), and in participants' interests in other consumer product information, including the amount of fentanyl and what other

Table 3
Drug checking easibility survey results among people who use drugs: Baltimore, Boston, and Providence, USA, 2017.

Characteristic	Baltimore		Boston		Providence		Total	
	N = 175		N = 80		N = 79		N = 334	
	No.	%	No.	%	No.	%	No.	%
Interested in drug checking [somewhat interested, interested, very interested]	148	84.6	68	85.0	68	86.1	284	85.0
Drug checking would make them feel better about protecting themselves from overdose *	150	86.7	75	93.8	72	91.1	297	89.5
Use behavior change due to drug checking	120	68.6	53	66.3	60	75.9	233	69.8
Not use / throw away the drugs with fentanyl	54	30.9	8	10.0	25	31.7	86	26.1
Stop using supplier who sold drugs with fentanyl	23	13.1	13	16.3	4	5.1	40	12.0
Use less of the drugs with fentanyl	16	9.1	14	17.5	8	10.1	38	11.4
Would ask seller to check drugs ***	56	32.4	48	60.0	23	29.1	127	38.3
Drug checking implementation								
Drug checking interest by information type								
Amount of fentanyl in drugs *	142	81.1	72	90.0	73	92.4	287	85.9
Cutting agents/drugs other than fentanyl *	145	82.9	74	92.5	73	92.4	292	87.4
Drug checking interest by technology/location								
On-site machine **	117	66.9	66	82.5	68	86.1	251	75.1
On-site fentanyl checking strip	132	75.4	66	82.5	62	78.5	260	77.8
Take-away fentanyl checking strip	154	88.0	73	91.3	70	88.6	297	88.9
If interested in drug checking…								
Would check drugs prior to consumption	146	98.7	63	92.7	67	98.5	276	97.2
Willing to give amount for drug checking equal to…								
Leftover residue from a baggie / pill to a couple of grains	49	32.9	32	45.1	21	29.6	102	35.0
A pinhead to a pinch / bump	50	33.5	27	38.0	27	38.0	104	35.7
Whatever it takes	43	28.9	6	8.5	20	28.2	69	23.7
Drug checking frequency (were it available)								
Daily	78	52.7	46	64.8	33	46.5	157	54.1
Weekly	49	33.1	18	25.4	31	43.7	98	33.8
Monthly or less	21	14.2	7	9.8	7	9.8	35	12.0

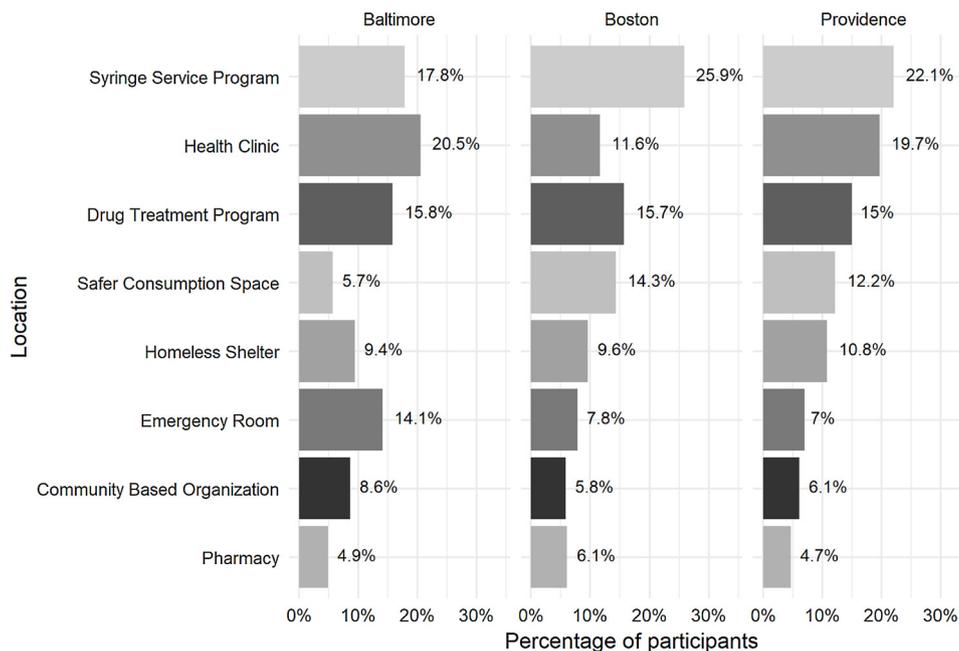Significance (Chi2 p-values): * - p < 0.05, ** p < 0.01, *** p < 0.001.

Fig. 1. Locations Identified by People Who Use Drugs as Sites to Access Drug Checking: Baltimore, Boston, and Providence, USA, 2017.

substances were mixed into their drugs (p < 0.05). Regarding checking technology, 89% reported interest in take-home FTS, 78% in on-site FTS, and interest in on-site drug checking machines differed significantly by city (p < 0.01). The vast majority (97%) of participants who expressed interest in drug checking reported they would check their drugs prior to consumption. The vast majority (94%) of respondents who expressed interest were willing to provide some portion of their drugs for drug checking, most commonly a pinhead or a pinch/bump (36%). Were drug checking available, the majority (54%)

of the interested participants expressed being willing to utilize it daily. When asked where drug checking would be most accessible, respondents identified a wide range of places, displayed in Fig. 1. SSPs were the most frequently mentioned site (58%) of interest across cities.

We examined factors associated with drug checking for fentanyl in bivariate and multivariate logistic regression (Table 4). In a multivariate model, interest in drug checking was independently associated with: being 35 years or older (aOR: 1.49, 95% CI: 1.26–1.78); race/ethnicity other than non-Hispanic white (aOR: 2.03, 95% CI:

Table 4

Correlates of Interest in Drug Checking Among People Who Use Drugs: Baltimore, Boston, and Providence, USA, 2017.

Variable	Bivariate		Multivariate	
	OR	95% CI	aOR	95% CI
Age				
< 35	1	(Ref)	1	(Ref)
> = 35	1.96	(1.30–2.95)	1.49	(1.26–1.78)
Race / Ethnicity				
NH white	1	(Ref)	1	(Ref)
All other race / ethnicities	2.09	(1.25–3.49)	2.03	(1.04–3.96)
Currently homeless	0.60	(0.49–0.72)	0.62	(0.53–0.73)
Ever witnessed a fatal overdose	1.34	(0.98–1.85)	1.57	(1.05–2.34)
Used drug suspected to contain fentanyl, last 6 months	1.41	(0.89–2.26)	1.82	(1.07 – 3.10)
Prefers fentanyl	0.57	(0.31–1.07)	0.66	(0.28–1.58)
Drugs with fentanyl taste, smell, or look differently	1.30	(0.91–1.84)	1.00	(0.78–1.28)

Robust standard errors were used to account for clustering by city of recruitment.

Notes. OR = odds ratio; CI = confidence interval; aOR = adjusted odds ratio; NH = non-Hispanic.

1.04–3.96); current homelessness (aOR: 0.62, 95% CI: 0.53–0.73); having witnessed a fatal overdose (aOR: 1.57, 95% CI: 1.05–2.34); and recently having used drugs suspected of containing fentanyl (aOR: 1.82, 95% CI: 1.07–3.10). A sensitivity analysis restricting the multivariate model to only people who recently used illicit opioids (n = 308) was run with the only qualitative difference affecting interpretation being the fentanyl detection via taste, smell, or look variable, which became significantly associated with a greater odds of interest (aOR: 1.23, 95% CI: 1.10–1.37).

Discussion

We found high interest in drug checking among a sample of structurally vulnerable PWUD who reported high rates of experiencing and witnessing overdoses, and high levels of suspected exposure to non-medical fentanyl. This study, conducted in three different cities amid a fentanyl-related overdose epidemic, is among the first to examine PWUDs' interest and perceptions towards specific types of drug checking services that can detect fentanyl in multiple settings. The inclusion of people who consume a variety of drugs (e.g., heroin, cocaine, methamphetamines, non-prescribed pharmaceutical opioids) through varying routes of administration (e.g., smoking, snorting, injecting) provides insights into drug checking acceptability among a broad range of PWUD. While the vast majority were interested in drug checking and reported willingness to modify drug use behavior in response to a fentanyl-positive result, an even higher percentage expressed that drug checking would help them protect themselves from overdose. The majority of interested respondents expressed a willingness to utilize drug checking at least daily, providing amounts of their drugs sufficient for chemical analysis via most types of drug checking technology. In addition to interest in knowing about the presence or absence of fentanyl, participants expressed interest in other product safety information, such as the amount of fentanyl and presence of additional substances. Participants supported both take-home and on-site drug checking services, illustrating how drug checking could be implemented as a part of comprehensive harm reduction services.

Regarding overdose experiences, nearly two-thirds of participants reported having ever overdosed. Almost half overdosed in the past year (most reporting multiple overdoses), with the great majority suspecting fentanyl was involved. Prior overdose is a strong predictor of subsequent nonfatal and fatal overdoses (Coffin et al., 2007; Darke, Mills, Ross, & Teesson, 2011; Evans, Tsui, Hahn, Davidson, & Lum, 2012) with increased odds after each overdose (Darke et al., 2007). While naloxone

can reverse an overdose after it occurs, drug checking represents a novel, preventative, PWUD-controlled tool that provides an objective method of verifying fentanyl presence; this is supported by our finding that 97% of PWUD reported wanting to use drug checking prior to drug use. Rates of witnessing a fatal overdose were close to double that of an earlier study among PWUD in New York City (Bohnert, Tracy, & Galea, 2012), reflective of the increased rate of overdose which is characterized by high rates of trauma. Witnessing a fatal overdose was significantly associated with an increased odds of drug checking interest. These findings suggest the salient roles of witnessing and experiencing overdose in the adaptation of preventative behaviors.

Participants employed a variety of subjective techniques to detect fentanyl, including reliance on taste, smell, or appearance. These methods are not always reliable and complicated by multiple adulterants with a white powder appearance similar to that of fentanyl (Mars, Ondocsin, & Ciccarone, 2018). It is possible that a participant's self-reported ability to detect fentanyl would limit their interest in having those suspicions confirmed objectively. However, among participants who felt they could perceive fentanyl adulteration, the vast majority (89%) still wished they had known "for sure," a finding reflected in the non-significance of this variable in the multivariate model. Suspected recent exposure to fentanyl led to a near doubling of the odds of drug checking interest, controlling for a preference for fentanyl, suggesting an interest in confirmation regardless of individual preference.

Only a quarter of the sample expressed a preference for fentanyl. These participants still had high levels of concern about fentanyl and interest in drug checking, adding nuance to concerns that drug checking will enable fentanyl "seeking" behavior and unintended adverse outcomes. Such suppositions ignore that for many opioid users, fentanyl consumption is unavoidable, given its penetration into heroin markets; it is possible some young PWUD have used more fentanyl than heroin. Contrary to these concerns, provision of drug checking services to PWUD may provide knowledge that helps reduce overdose risk (Krieger et al., 2018): a study in Vancouver found that a positive fentanyl result was associated with a higher odds of overdose reduction (Karamuzian et al., 2018). Given the level of concern about fentanyl and interest in drug checking observed in the varied city contexts within this study, we underscore the need for harm reduction messaging as well as ethnographic and further quantitative research to help understand the nature of local drug markets and context of individual preferences when implementing drug checking schemes (McGowan, Harris, Platt, Hope, & Rhodes, 2018). Participants in our study identified services and locations which already exist and they already utilize, such as SSPs, health clinics, and substance use treatment centers, as potential places which could incorporate drug checking into their umbrella of existing services.

Participants were most interested in FTS, which are increasingly being distributed through SSPs in North America. Participants were also interested in on-site machines given their more detailed output, but their use is complicated by concerns about legality, the trust needed to bring drugs to a locale, and upfront expense. U.S. cities have begun decriminalizing drug checking paraphernalia and permitting the distribution and possession of harm reduction materials, as recently occurred in Washington, DC (DC Act 22-211, 2017), Rhode Island (S 2896, 2018), and Maryland (S 1137, 2017). Such decriminalization will likely pave the way for future on-site drug checking programs. Regardless of the nature of the technology, drug checking provides a unique opportunity for engagement with PWUD and the dissemination of harm reduction messaging, such as taking "tester shots," having multiple doses of naloxone on hand, and calling 911 or equivalent emergency response services in the event of a suspected overdose. Additionally, interested participants in our study demonstrated a willingness to use such drug checking interventions on a regular basis, with over half (54%) reporting willingness to check their drugs at least daily.

Our findings also indicate that targeted outreach may be required by drug checking programs in order to engage subpopulations (younger PWUD, non-Hispanic whites) expressing lower levels of interest in drug

checking. Non-Hispanic white PWUDs' significant lack of interest is concerning, given that current rates of opioid overdoses and subsequent emergency department admissions are highest among this population. People experiencing homelessness had a significantly reduced odds of drug checking interest in a bivariate analysis. Upon further exploration (data not shown), we found that people experiencing homelessness were significantly less likely to throw away drugs that were suspected of fentanyl, indicating a likely inability to replace drugs even if there was suspicion of fentanyl. Given the persistence of homelessness as a consistent risk factor for overdose, this finding merits further exploration (Baggett et al., 2013; Park et al., 2018).

Recruitment methods differed in Baltimore compared to Boston and Rhode Island, which may have contributed to measured and unmeasured confounding by site. Other between-site variations in drug use patterns, local drug supply, and level of fentanyl adulteration in markets may also impact comparability. Survey data may be subject to recall bias and social desirability, though the use of ACASI could serve to minimize social desirability bias in responses about stigmatized behaviors such as illicit drug use (Adebajo, Obianwu, & Eluwa, 2014). Given high rates of fentanyl-related overdose in the three cities, survivor bias could have influenced the sample. While not measured in this study, law enforcement approaches, including recent implementation of drug-induced homicide provisions targeting people who provide fentanyl-laced drugs (Drug Policy Alliance, 2017) and drug paraphernalia laws, may impact participants' willingness to report their openness to drug checking.

Drug checking represents a potentially important and underutilized component of a holistic public health response to the overdose epidemic. Given the extent and growth of fentanyl-adulterated drug markets throughout the U.S., there is an urgent need to implement appropriate interventions and expand evidence-based treatment. Providing PWUD with empowering tools, such as access to drug checking services and associated harm reduction counseling, is relatively inexpensive and lifesaving. Drug checking introduces a degree of consumer information to PWUD, informing educated decisions on drug use. Tools that empower PWUD to make informed decisions to protect their own health are a vital component of any meaningful and comprehensive plan to reduce the burden of opioid overdose.

Conflict of interest

The authors do not have any financial or personal interest or belief that could affect their objectivity.

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