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The impact of polysubstance use patterns on engagement of substance use disorder treatment among emergency department patients at high risk of opioid overdose

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ABSTRACT

Background: Substance use patterns are diverse, and multiple substances are often involved in fatal and nonfatal overdoses. Additionally, polysubstance use is associated with greater difficulty accessing and remaining in substance use disorder (SUD) treatment. The aim of this study was to identify substance use patterns and determine their association with SUD treatment engagement among emergency department (ED) patients at risk of opioid overdose.

Methods: This was a sub-analysis of a randomized controlled trial comparing two behavioral interventions for individuals at two EDs in Rhode Island from 2018 to 2021. Past six-month substance use frequency for eight substances plus injection drug use was self-reported at trial enrollment, and SUD treatment engagement within 90 days after enrollment was obtained using administrative data linkages. Latent class analysis identified substance use patterns and multivariable log-binomial models estimated the association with SUD treatment engagement.

Results: Among 607 participants, there were four substance use patterns: 1) low reported use (n = 295), 2) frequent injection and heroin use (n = 131), 3) high frequency broad polysubstance use (n = 62), and 4) low frequency broad polysubstance use (n = 119). Compared to participants with the low reported use pattern, those with the frequent injection and heroin pattern had a greater likelihood of SUD treatment engagement (adjusted risk ratio = 1.28; 95% confidence interval = 1.02–1.61).

Conclusions: Distinct and meaningful polysubstance use patterns showed differential SUD treatment engagement after ED discharge. Nuanced relationships between substance use patterns and treatment highlight the necessity for tailored harm reduction, treatment, and recovery services.

1. Introduction

Most drug-involved deaths in the United States (US) involve more than one drug (Black et al., 2023; Substance Abuse and Mental Health Services Administration, 2021). The number of overdose deaths involving non-opioid substances such as cocaine and methamphetamine has substantially increased from 2014 to 2020 (National Institute on Drug Abuse, 2022). These substances were also listed among the top five drugs involved in drug-related emergency department (ED) visits (Drug Abuse Warning Network, 2022). Moreover, among people with opioid use disorder (OUD), use of non-opioid substances significantly reduces access and adherence to medications for opioid use disorder (MOUD) (Ford et al., 2021; Frost et al., 2021; Krawczyk et al., 2021; Lin et al., 2020; Mackay et al., 2021). Co-occurring stimulant use may be particularly impactful on substance use disorder (SUD) treatment access and retention – recent studies have demonstrated over 50% reduction in six-month retention among people who use methamphetamine while receiving MOUD (Ford et al., 2021; Frost et al., 2021; Krawczyk et al.,

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2021; Mackay et al., 2021). While there is evidence that polysubstance use is associated with worse SUD treatment access and outcomes, little is known about the impact of polysubstance use on SUD treatment engagement among individuals attending EDs at high risk of overdose.

EDs are increasingly viewed as an opportunity to intervene on behavioral health issues and provide a pathway to SUD treatment services (Hawk et al., 2019). In many states, certified peer recovery specialists and licensed clinical social workers use evidence-based interviewing and intervention techniques to provide timely ED-based interventions to address both immediate (e.g., naloxone distribution) and long-term (e.g., treatment access, recovery support) goals (Gormley et al., 2021; Hawk & D'Onofrio, 2018). While the current literature describes implementation challenges and various patient-level outcomes in the ED (e.g., receipt of naloxone, buprenorphine initiation, referral to SUD treatment services), few studies have interrogated the impact of polysubstance use patterns on SUD treatment engagement following receipt of an ED-based behavioral intervention and discharge from the ED.

There is a need to understand the role of polysubstance use in the ED environment to inform best practices to care for this high-risk population. Utilizing data collected as part of an ED-based trial of behavioral interventions, this secondary analysis sought to examine the association between polysubstance use patterns and subsequent engagement with SUD treatment among ED patients who are at high risk of subsequent opioid overdose. Given the heterogeneity of substance use patterns observed in this patient population, a data-driven approach was used to identify latent substance use classifications in the study sample and their subsequent relationship to engaging in licensed SUD treatment. The leading hypothesis was that distinct polysubstance patterns would be observed in the high risk ED population, specifically patterns comprising preferential use of either non-injectable polysubstances, injectable polysubstances, and prescription opioids or depressants. Furthermore, these distinct patterns would have differential SUD treatment engagement following an ED visit.

2. Material and methods

2.1. Study population and design

All participants enrolled in the Navigator Trial—a randomized controlled trial of a behavioral intervention for individuals presenting at the ED at high risk of subsequent opioid overdose (ClinicalTrials.gov identifier: NCT03684681)—were eligible for inclusion in this analysis. As previously described, the Navigator Trial was conducted at two EDs in Rhode Island from 2018 to 2021 and recruited adults who resided in or received most of their health care in Rhode Island and were at high risk for subsequent opioid overdose (i.e., the ED visit was due to an opioid overdose, they received OUD-related treatment at the ED visit, or had an opioid overdose in the past 12 months as identified from self-report or electronic health record review). Individuals who were pregnant, in police custody, or could not communicate in English were not eligible to participate in the trial. Detailed participant eligibility and trial enrollment procedures have been published elsewhere (Goedel et al., 2019). Enrolled participants were randomized to receive behavioral counseling at the time of the ED visit from either a licensed clinical social worker (LCSW; control arm) or a certified peer recovery specialist (CPRS; intervention arm). Participants in the intervention arm received continuous CPRS engagement for up to 90 days, while interactions between LCSW and participants often only occurred during the ED visit. Participants received a $40 gift card as compensation for their time and provided informed consent. The study was reviewed and approved by the study sites' institutional review boards. The characteristics of all enrolled participants, as well as the results for the primary trial outcome, have been previously published (Beaudoin et al., 2022).

2.2. Measures

At baseline (i.e., ED visit when participants enrolled into the trial from 2018 to 2021), participants completed a comprehensive behavioral questionnaire that included sociodemographics, substance use history, and prior addiction treatment, among other domains. Frequency of substance use in the past six months was recorded for heroin, cocaine, crystal methamphetamine, extra-medical use of prescription opioids (i.e., use without a prescription or not as directed by a prescriber), extra-medical use of prescription benzodiazepines, cannabis, club drugs (i.e., MDMA, GHB, ketamine, mushrooms), and six or more drinks on one occasion (i.e., heavy episodic alcohol use) (World Health Organization, 2023). Participants also reported frequency of injection drug use in the past six months. The frequency responses for heroin, cocaine, prescription opioids, cannabis, alcohol, and injection drug use were categorized as: none, a few times to monthly, weekly, or daily. Responses for prescription benzodiazepine, crystal methamphetamine, and club drugs were categorized as: none, a few times to monthly, and weekly or daily, due to the relatively small number of responses in the latter categories for these substances. Participants who did not complete any of the substance use frequency questions were excluded from the analysis.

The primary outcome for this study was engagement of any SUD treatment within 90 days of trial enrollment, per linkage to statewide administrative treatment data from the Behavioral Health Online Database and the Prescription Drug Monitoring Program. The Behavioral Health Online Databases includes admission and discharge information from SUD treatment providers licensed by the Rhode Island Department of Behavioral Healthcare, Developmental Disabilities and Hospitals, including methadone, outpatient, intensive outpatient, residential detoxification, and residential treatment. The Prescription Drug Monitoring Program database includes all buprenorphine prescriptions dispensed by retail pharmacies to Rhode Island residents, as well as prescriptions dispensed by most out-of-state retail pharmacies. SUD treatment engagement was defined as any (1) new SUD treatment episode at a publicly-licensed program or (2) fill of a buprenorphine MOUD prescription (all formulations) within 90 days of the baseline ED visit. A new SUD treatment episode at a publicly-licensed program includes new SUD treatment initiation after trial enrollment, however this can also include participants who were enrolled in a SUD treatment within 30 days prior to trial enrollment and after enrollment switched to a new provider or changed to a different SUD treatment type, and/or initiated additional SUD treatments (including MOUD). Prior work evaluating engagement in SUD treatment within 30 days of trial enrollment in the Navigator trial identified a relatively low prevalence of participants engaging in SUD treatment services, so to allow enough time for participants to enter treatment, the time to engagement in SUD treatment in this analysis was expanded to 90 days (Beaudoin et al., 2022).

2.3. Statistical analysis

Descriptive statistics were used to characterize study participants, stratified by the primary outcome (i.e., engagement of any SUD treatment within 90 days of trial enrollment). The characteristics of participants included in the analysis were compared to those who did not meet inclusion criteria to ensure no systematic differences between those excluded. Because the outcome definition included participants who could be enrolled in SUD treatment 30 days prior to trial enrollment, baseline characteristics of participants who had not engaged in any SUD treatment 30 days prior to trial enrollment were also assessed as sensitivity analysis to determine if they differed on risk factors from the study population that contained a mix of SUD treatment naive and experienced participants.

Next, latent class analysis (LCA) was used to identify patterns of past six-month polysubstance use at the time of trial enrollment (Asparouhov & Muthén, 2014). Initial class enumeration was conducted by estimating

models with increasing numbers of classes until information criteria showed worsening model fit, without inclusion of covariates. Determination of the best fitting model was based on comparison of four model fit statistics: entropy, Bayesian Information Criteria, Akaike's Information Criteria, and bootstrapped likelihood ratio tests. In the event that there was disagreement between the indices of fit, preference was given to the bootstrapped likelihood ratio tests. Clinical relevance and interpretability were also considered in choosing the final number of classes. Using the three-step LCA approach, participants were assigned to the class with their highest probability of membership, and the primary outcome was regressed on the latent class variable. Covariate adjustment included a variable for intervention arm and other variables known to be associated with polysubstance use and healthcare access among vulnerable populations. These variables were added into the model in the following sequential order: 1) demographics (non-White race or Hispanic ethnicity, age, current gender identity); 2) social determinants of health (housing stability, employment status, education, marital status); and 3) SUD treatment need or history (opioid overdose in the last 12 months, barriers to SUD treatment access, self-reported psychiatric diagnosis). Inclusion of intervention arm in the regression model was done to increase precision in the estimated coefficients. To avoid overfitting, only statistically significant covariates for social determinants of health were carried over to the final model that included covariates for demographics and SUD treatment need or history. Participant self-report of ever receiving buprenorphine or methadone MOUD were not included as covariates in the model to avoid collinearity.

In sensitivity analyses we assessed whether there was differential engagement of MOUD treatment only (i.e., buprenorphine MOUD via prescription or methadone MOUD from a publicly-licensed program) within the same timeframe. The same three-step LCA approach described above was repeated for the MOUD treatment only outcome. As the study outcomes were derived from statewide administrative data in Rhode Island, we assumed minimal missingness and that if data were missing it was completely at random. Descriptive statistical analyses were conducted using SAS version 9.3 (SAS Institute, Inc; Cary, NC) and the LCA approach was conducted in M*plus* version 8.8 (Muthen & Muthen; Los Angeles, CA).

3. Results

Of the 648 participants randomized in the Navigator Trial, 607 (94%; 308 from the LCSW arm and 299 from the CPRS arm) reported their substance use in the six months before trial enrollment and were included in this analysis. Sociodemographic characteristics of excluded participants were similar to those of included participants (Supplementary Table 1). Among the 607 participants in the current analysis, most identified as men (68%) and non-Hispanic White (66%) with a mean age of 36.8 years (standard deviation: 10.8) (Table 1). The majority of participants (510 of 607 [84%]) reported adverse social determinants of health, including unstable housing (44%), current unemployment (70%), and a current monthly income of $0 (25%). More than half of participants (411 of 607 [68%]) presenting to the ED reported an opioid overdose in the past 12 months. Substance use in the six months before trial enrollment was high, with almost all participants reporting using at least one substance (592 of 607 [98%]). The most common substances reported were prescription opioids extra-medically (64%), cocaine (58%), heroin (56%), cannabis (66%), and heavy episodic alcohol use (45%). Fewer participants reported prior six-month use of prescription benzodiazepines extra-medically (25%), crystal methamphetamine (23%), injection drug use (39%), and club drugs (i.e., MDMA, GHB, ketamine, mushrooms; 28%). Lastly, >50% of participants reported using fentanyl (intentionally or unintentionally) in the six months before trial enrollment. At baseline there were 166 participants who reported SUD treatment 30 days prior to trial enrollment. To confirm that these participants were not substantially different on

Table 1
Baseline characteristics of Navigator Trial participants included in the polysubstance use analysis (n = 607).

	Engagement of SUD treatment within 90 days of trial enrollment		*p-value*
	No [n (%)] (n = 344)	Yes [n (%)] (n = 263)	
Age [mean(SD)]	36.99 (11.43)	36.58 (9.99)	0.64
Gender identity[a]			0.52
Woman	113 (32.85)	80 (30.42)	
Man	231 (67.15)	183 (69.58)	
Race-ethnicity			0.98
White, non-Hispanic	230 (66.86)	170 (64.64)	
Black, non-Hispanic	20 (5.81)	16 (6.08)	
Hispanic, any race	57 (16.57)	45 (17.11)	
Other, non-Hispanic	35 (10.17)	30 (11.41)	
Missing	2 (0.58)	2 (0.76)	
Marital Status			0.40
Single or widowed	208 (60.47)	173 (65.78)	
Married or with partner	134 (38.95)	89 (33.84)	
Missing	2 (0.58)	1 (0.38)	
Completed high school education			0.30
No	94 (27.33)	86 (32.70)	
Yes	249 (72.38)	176 (66.92)	
Missing	1 (0.29)	1 (0.38)	
Health insurance			0.02
No	35 (10.17)	12 (4.56)	
Yes	302 (87.79)	242 (92.02)	
Missing	7 (2.03)	9 (3.42)	
Unstable housing in past six months			<0.001
No	219 (63.66)	116 (44.11)	
Yes	124 (36.05)	144 (54.75)	
Don't know	1 (0.29)	3 (1.14)	
Currently employed full or part-time			0.09
No	230 (66.86)	196 (74.52)	
Yes	112 (32.56)	65 (24.71)	
Missing	2 (0.58)	2 (0.76)	
Current monthly income			0.23
$0–$1500	228 (66.28)	188 (71.48)	
>$1501	94 (27.33)	56 (21.29)	
Don't know	22 (6.40)	19 (7.22)	
Past six-month substance use			
Prescription opioids			0.05
No	126 (36.63)	75 (28.52)	
Yes	210 (61.05)	176 (66.92)	
Missing	8 (2.33)	12 (4.56)	
Prescription benzodiazepine			0.06
No	258 (75.00)	174 (66.16)	
Yes	75 (21.80)	77 (29.28)	
Missing	11 (3.20)	12 (4.56)	
Cannabis			0.49
No	99 (28.78)	85 (32.32)	
Yes	235 (68.31)	168 (63.88)	
Missing	10 (2.91)	10 (3.80)	
Crystal methamphetamine			0.02
No	267 (77.62)	180 (68.44)	
Yes	65 (18.90)	75 (28.52)	
Missing	12 (3.49)	8 (3.04)	
Cocaine			0.10
No	145 (42.15)	90 (34.22)	
Yes	189 (54.94)	161 (61.22)	

(*continued on next page*)

Table 1 (*continued*)

	Engagement of SUD treatment within 90 days of trial enrollment		*p-value*
	No [n (%)] (n = 344)	Yes [n (%)] (n = 263)	
Missing	10 (2.91)	12 (4.56)	
Heroin			0.07
No	152 (44.19)	93 (35.36)	
Yes	181 (52.62)	157 (59.70)	
Missing	11 (3.20)	13 (4.94)	
Club drugs			0.71
No	240 (69.77)	183 (69.58)	
Yes	94 (27.33)	75 (28.52)	
Missing	10 (2.91)	5 (1.90)	
Heavy episodic alcohol use			0.18
No	166 (48.26)	140 (53.23)	
Yes	166 (48.26)	109 (41.44)	
Missing	12 (3.49)	14 (5.32)	
Injection drug use			0.02
No	211 (61.34)	135 (51.33)	
Yes	118 (34.30)	119 (45.25)	
Missing	15 (4.36)	9 (3.42)	
Opioid overdose in past 12 months			0.70
No	105 (30.52)	89 (33.84)	
Yes	238 (69.19)	173 (65.78)	
Missing	1 (0.29)	1 (0.38)	
Prior SUD treatment (past one-month)			<0.0001
No	290 (84.30)	151 (57.41)	
Yes	54 (15.70)	112 (42.59)	
Ever received methadone treatment			0.07
No	222 (64.53)	151 (57.41)	
Yes	122 (35.47)	112 (42.59)	
Ever received Suboxone™ treatment			<0.0001
No	250 (72.67)	137 (52.09)	
Yes	94 (27.33)	126 (47.91)	
Ever experienced barrier to treatment access			<0.01
No	239 (69.48)	142 (53.99)	
Yes	99 (28.78)	117 (44.49)	
Don't know/Refused	6 (1.74)	4 (1.52)	

[a] Gender identity includes both cis and trans individuals.

important confounders, they were excluded and the characteristics of the remaining participants were compared to the total study population (Supplementary Table 2). As no differences were observed between the reduced sample and the total study population, the analysis proceeded with the 607 participants.

3.1. Latent class estimation

After running the three-step LCA approach, a four-class model was selected as providing the best description of underlying polysubstance use patterns in the study population according to the model fit statistics, clinical relevance, and interpretability (Supplementary Table 3). The bootstrap-likelihood ratio test was > 0.05 when comparing the five-class with the four-class model, suggesting the latter provided the best fit.

Each of the classes comprising the four-class model were of sufficient size, well-defined, and easily interpretable (Fig. 1). The largest class (n = 295) was characterized predominantly by the absence of prescription benzodiazepines, crystal methamphetamine, cocaine, heroin, injection drugs, and club drug use. Of the substances reported in this class, frequency of use was most often monthly or less, except for cannabis. Due to this observed pattern, this class was labeled as "Low reported use". The second class (n = 131) was characterized by a high likelihood of daily drug injection and heroin use, and lower likelihood of endorsing crystal methamphetamine, cocaine, cannabis, heavy episodic alcohol use, prescription benzodiazepines, and club drugs. This class was termed the "Frequent injection and heroin use" pattern. The third class (n = 62) was characterized predominantly by weekly or more frequent use of prescription opioids, heroin, cocaine, and cannabis. Because weekly use of club drugs and heavy episodic alcohol use was highest in this class compared to others, this class was termed the "High frequency broad polysubstance use" pattern. The last class was termed the "Low frequency broad polysubstance use" pattern (n = 119) and was characterized predominantly by monthly use of prescription opioids, heroin, cocaine, injection drug use, crystal methamphetamine, and club drugs. The latent class probabilities for each substance that guided interpretation of the four polysubstance use patterns are outlined in Supplementary Table 4 and baseline characteristics by these four polysubstance use patterns are compared in Supplementary Table 5.

3.2. Outcome analysis

In total, 263 (43%) participants engaged in any SUD treatment within 90 days of trial enrollment. Engagement of SUD treatment was lowest among participants in the "Low reported use" pattern (37%) and highest among participants in the "Frequent injection and heroin use" pattern (53%). In the regression model adjusting for intervention arm only (Table 2: Model 1), the likelihood of engaging in SUD treatment within 90 days of trial enrollment was 43% greater in the "Frequent injection and heroin use" pattern (risk ratio [RR]: 1.43; 95% confidence interval [CI]: 1.14–1.78) and 27% greater in the "Low frequency broad polysubstance use" pattern (RR: 1.27; 95% CI: 1.00–1.62), relative to those in the "Low reported use" pattern. This remained true after adjusting for demographic characteristics (Table 2: Model 2); however, after including social determinants of health (Table 2: Model 3) and variables for SUD need or history (Table 2: Model 4), only the "Frequent injection and heroin use" pattern had a higher likelihood of engaging in SUD treatment within 90 days of trial enrollment (RR: 1.28; 95% CI: 1.02–1.61) compared to the "Low reported use" pattern. The "High frequency broad polysubstance use" pattern did not considerably differ from the referent pattern in any model.

3.3. Sensitivity ***analysis***

In sensitivity analyses, 193 (32%) participants received only MOUD treatment within 90 days of trial enrollment, and was most common among the "Frequent injection and heroin use" (38%) and "High frequency broad polysubstance use" (36%) patterns. Consistent with the main analysis, the "Frequent injection and heroin use" pattern had a significantly increased likelihood of MOUD treatment within 90 days of trial enrollment relative to the "Low reported use" pattern (RR: 1.37; 95% CI: 1.03–1.83; Supplementary Table 6: Model 1). After including demographic covariates this association remained (RR: 1.38; 95% CI: 1.03–1.84; Supplementary Table 6: Model 2). While a similar trend was observed for the other polysubstance use patterns as in the main analysis, findings were not statistically significant.

4. Discussion

This study identified four distinct patterns of polysubstance use among people at high risk of opioid overdose presenting to EDs in Rhode Island: 1) Low reported use, 2) Frequent injection and heroin use, 3) High frequency broad polysubstance use, and 4) Low frequency broad

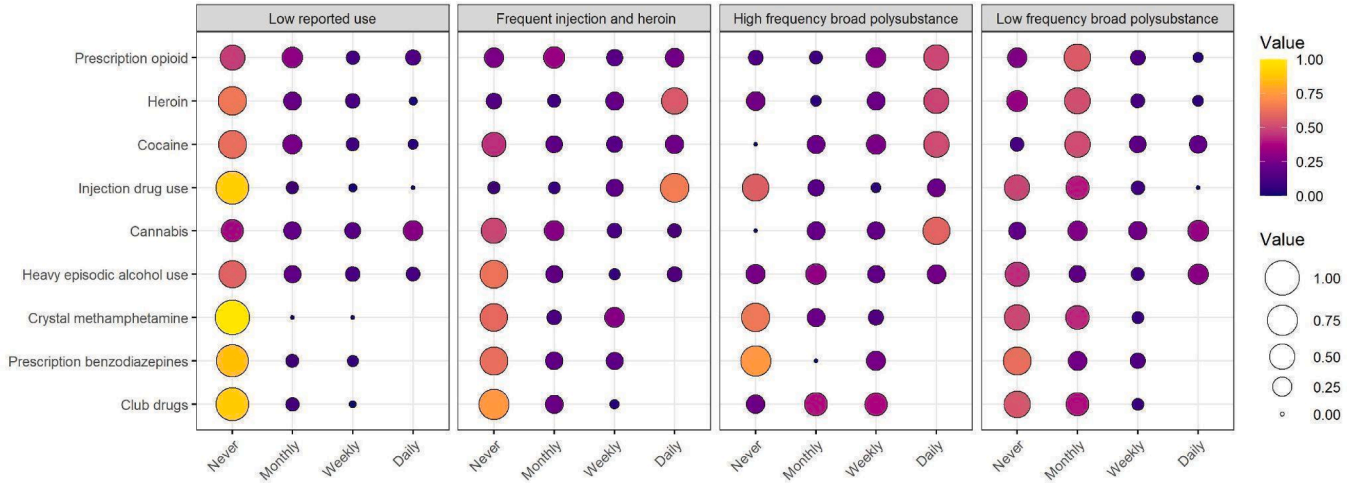

Fig. 1. Polysubstance use probabilities of the four-class model among Navigator Trial participants (n = 607). Balloon plot showing the item-response probabilities for the frequency of use (x-axis) for each substance (y-axis) included in the LCA model for the four-class model. The magnitude of each probability is represented by the size and the color of each circle in the corresponding legend to the left of the image. Larger circles and brighter colors represent higher probabilities. Daily frequencies for crystal methamphetamine, prescription benzodiazepines, and club drugs are captured in the weekly category due to the small number of responses.

Table 2
Log-binomial regression models for the association between polysubstance use patterns and 90-day SUD treatment engagement in Navigator Trial participants (n = 607).

	Model 1		Model 2		Model 3		Model 4[a]	
	aRR	95% CI	aRR	95% CI	aRR	95% CI	aRR	95%CI
Substance use pattern								
Low reported use	1.00		1.00		1.00		1.00	
Frequent injection and heroin use	**1.43**	**1.14, 1.78**	**1.47**	**1.17, 1.84**	**1.35**	**1.07, 1.70**	**1.28**	**1.02, 1.61**
High frequency broad polysubstance use	1.27	0.93, 1.72	1.27	0.94, 1.73	1.14	0.84, 1.54	1.09	0.81, 1.48
Low frequency broad polysubstance use	**1.27**	**1.00, 1.62**	**1.29**	**1.01, 1.65**	1.20	0.94, 1.53	1.13	0.88, 1.44
Interventionarm	1.03	0.86, 1.23	1.02	0.85, 1.22	1.04	0.88, 1.24	1.07	0.90, 1.27
Demographics								
Race-ethnicity								
White, non-Hispanic			Ref	Ref	Ref	Ref	Ref	Ref
Black, non-Hispanic			1.20	0.81, 1.77	1.19	0.82, 1.74	1.12	0.77, 1.63
Hispanic			1.07	0.84, 1.36	1.01	0.80, 1.29	1.04	0.82, 1.32
Other			1.12	0.85, 1.48	1.07	0.81, 1.42	1.09	0.82, 1.44
Woman gender identity			0.93	0.76, 1.14	0.92	0.76, 1.13	0.92	0.76, 1.12
Age (continuous)			1.00	0.99, 1.01	1.00	0.99, 1.01	1.00	0.99, 1.01
Social determinants of health								
Unstable housing					**1.46**	**1.19, 1.79**	**1.43**	**1.17, 1.74**
Employment					0.95	0.74, 1.22		
Education					0.92	0.76, 1.11		
Marital status					0.98	0.81, 1.20		
Substance treatment need/history								
Opioid overdose in the last 12 months							0.94	0.79, 1.14
Barriers to SUD treatment access							**1.25**	**1.03, 1.52**
Self-reported psychiatric diagnosis							0.91	0.70, 1.20

[a] Model used for interpreting main analysis.

polysubstance use. After adjusting for intervention arm, the "Frequent injection and heroin use" and "Low frequency broad polysubstance use" groups were associated with an increased likelihood of SUD treatment engagement within 90 days after ED discharge when compared to the "Low reported use" group. Similar results were observed in sensitivity analyses when examining engagement of MOUD only. The increased likelihood of SUD treatment engagement may reflect differing access to care and resources, as well as differing treatment needs, across these polysubstance use patterns. This work advances the understanding of engagement of SUD treatment by providing a nuanced characterization of patterns of polysubstance use in a population at high risk for opioid overdose.

Our latent class model aligns with the literature on the number (n = 4) and type of classes (or patterns) identified, although our study was one of the few to assess injection drug use in addition to substance use (Blow et al., 2011; Karamouzian et al., 2022; Liu & Vivolo-Kantor, 2020; Tomczyk et al., 2016). Injection drug use is indicative of a severe substance use pattern that leads to increased risk of HIV and hepatitis C and is therefore an important source of comorbidity among this study population (Chhabra et al., 2022; Fong et al., 2015). This analysis also included heavy episodic alcohol use in determination of latent class patterns, which is a common comorbidity often untreated among people with other types of SUD (Suen et al., 2022). A recent evaluation of polysubstance use patterns among recipients of an ED-based opioid overdose prevention program in New Jersey, US, identified five latent classes: heroin/polysubstance use, prescription drug/cannabis use, prescription drug/polysubstance use, cannabis/fentanyl/cocaine/methamphetamine use, and alcohol/benzodiazepine/polysubstance use

(Lardier et al., 2022). However, frequency of use was not considered in this analysis, and polysubstance use was measured on a binary scale. Our current study adds to the literature by identifying patterns of drug use using scales that capture frequency of drug use among people at high risk of opioid overdose (i.e., including individuals presenting at the ED for reasons other than opioid overdose) and who received an ED-based behavioral intervention from either a CPRS or LCSW. Given that not all states utilize CPRS for opioid-related care in the ED and that LCSWs are the standard of care in Rhode Island, our study may be more generalizable to the population of patients presenting to the ED at risk of opioid overdose because participants received interventions reflective of the broader care landscape (Department of Behavioral Healthcare and Disabilities, 2017). Initial outcomes from the Navigator Trial demonstrated that approximately 30% of participants engaged in SUD treatment within the first 30 days of trial enrollment (Beaudoin et al., 2022). The current study extends this follow-up period to 90 days and identifies differential engagement of SUD treatment based on patterns of polysubstance use, with more than half of individuals in the "Frequent injection and heroin use," "High frequency broad polysubstance use," and "Low frequency broad polysubstance use" groups engaging in some form of care. And while not addressed in this study, it is possible that differences might exist in the relationship between the polysubstance use patterns and SUD treatment engagement by intervention arm.

The provision of ED-based post-overdose interventions is expanding; few randomized controlled trials have examined more distal SUD treatment outcomes of ED-based behavioral care models such as residential housing and MOUD treatment (Bagley et al., 2019). Quasi-experimental and observational studies of ED-based behavioral interventions demonstrate that implementing these novel models of care is feasible and increases MOUD treatment uptake, but few have assessed differential uptake of broader SUD treatment services (Jacka et al., 2021; Watson et al., 2021). Challenges in implementing ED-based, post-overdose interventions are vast but broadly fit within overarching areas of operations (e.g., timing of intervention, fast-paced environment, competing demands on staff time), interpersonal dynamics (e.g., mistrust between providers and peers), communication (e.g., between provider teams), lack of privacy for patients, and social and structural barriers (Collins et al., 2021; Crisanti et al., 2022; Watson et al., 2022). The current study extends our understanding of SUD treatment access in the Navigator Trial, and more broadly, by identifying distinctive polysubstance use patterns of patients with the highest support needs (i.e., more frequent consumption, injection drug use, polysubstance use).

Access to healthcare for vulnerable populations is often influenced by complex interactions of individual perceived need, access to support and resources, and structural discrimination (Gelberg et al., 2000). Participants in the Navigator Trial indicated a high readiness to engage in SUD treatment, with 85% reporting plans to change their drug use within 30 days of trial enrollment (Beaudoin et al., 2022). However, most participants reported a known adverse social driver of health, including housing instability, low income, unemployment, and prior difficulties accessing treatment. More broadly, availability and accessibility of services in the community and interactions with service providers greatly influence individual access to healthcare (Dixon-Woods et al., 2006). In particular, polysubstance use is associated with decreased treatment retention across all forms of opioid treatment programs, highlighting the need to specifically address co-occurring substance use in SUD treatment (Blondino et al., 2020). The state of Rhode Island enacted substantial policy and practice changes in 2016 in response to excessive drug overdose deaths, including multidisciplinary and multi-agency review of drug overdose deaths, statewide hospital standards for post-overdose intervention, and a comprehensive strategic plan to reduce overdose morbidity and mortality (Governor, 2021; Hackman et al., 2020; Samuels et al., 2021). Individuals with polysubstance use who present to the ED with opioid overdose are more likely to require inpatient treatment; however, need for OUD treatment exceeds availability in Rhode Island (Bhalla et al., 2017; Fanucchi et al., 2018; Samuels et al., 2019). There remains a need for coordinated and compassionate responses to SUD treatment and overdose prevention that incorporates the perspectives of people who use drugs (Braun et al., 2022; Krawczyk et al., 2022). While SUD treatment engagement was high in selected groups within the current study, substantial scale-up of services addressing polysubstance use (e.g., harm reduction, SUD and co-occurring mental health treatment, and recovery support services) and social determinants of health are necessary to reverse historical trends in overdose morbidity and mortality (Wakeman et al., 2019).

There are a number of limitations to this study. While the inclusion criteria led to a study population that more broadly represents individuals at high risk of subsequent overdose compared to studies that restrict enrollment to post-overdose ED visits, our study may not be generalizable to locations outside of Rhode Island. In addition, substance use frequency questionnaires were collected between 2018 and 2021, and may not reflect current substance use patterns in Rhode Island. Second, participant responses to substance use questions may be affected by social desirability bias, where participants may not want to disclose use of certain substances. Questionnaires were self-administered by participants and research assistants were separate from hospital care teams to address this concern. Third, participants may have had subsequent visits to the ED, contact with community-based organizations, and/or interactions with behavioral health providers as part of standard of care during the following-up period which might have influenced their likelihood of treatment engagement. In addition, overall treatment engagement may have been negatively impacted due to the COVID-19 pandemic. Fourth, administrative data linkage was not able to identify engagement of private treatment (besides buprenorphine) or licensed SUD treatment in states other than Rhode Island. Participants may have received addiction care in other states or received other forms of non-licensed SUD care (such as mutual aid). While statewide administrative data have advantages in passively capturing study outcomes, we were not able to ascertain whether participants were lost to follow-up due to mortality, and individuals with the greatest need for SUD treatment (those with injection drug use and polysubstance use) are at greatest risk for drug-related mortality. Fifth, while feedback from key state stakeholders and a practicing physician in addiction medicine was obtained in interpreting the polysubstance use patterns, we did not incorporate feedback from people with lived experiences of polysubstance use whose input is essential for identifying tailored harm reduction interventions for polysubstance use. Finally, we were not able to account for potential misclassification of individuals to latent classes by the LCA model, which possibly affected the association between polysubstance use patterns and the SUD treatment outcome.

5. Conclusions

In conclusion, this study of individuals presenting to EDs at high risk of subsequent opioid overdose demonstrates that there are identifiable patterns of polysubstance drug use and differential rates of SUD treatment engagement in these groups. An enhanced understanding of polysubstance use patterns is needed in order to target and tailor interventions accordingly. Different approaches are required for occasional users vs. daily polysubstance users, and individuals at risk of drug overdoses cannot be considered a homogenous group. There is a paucity of harm reduction and care coordination services that incorporate substance use patterns in the ED environment, as such future trials of ED interventions should consider incorporating them in the design and implementation of interventions for this high-risk population.

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CRediT authorship contribution statement

Fiona Bhondoekhan: Visualization, Writing – original draft, Writing – review & editing. **Yu Li:** Formal analysis, Methodology, Software, Validation, Data curation, Writing – review & editing. **Rachel Gaither:** Writing – review & editing. **Mackenzie Daly:** Writing – review & editing. **Benjamin D. Hallowell:** Data curation, Writing – review & editing. **Laura C. Chambers:** Project administration, Validation, Data curation, Writing – review & editing. **Francesca L. Beaudoin:** Conceptualization, Funding acquisition, Methodology, Supervision, Validation, Resources, Writing – review & editing. **Brandon D.L. Marshall:** Conceptualization, Funding acquisition, Methodology, Supervision, Validation, Resources, Writing – review & editing.

Declaration of Competing Interest

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

Data availability

Data will be made available on request.

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Appendix A. Supplementary material

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