A Mobile Health Tool to Capture Social Determinants of Health and their Impact on HIV Treatment Outcomes among People Who Use Drugs: Pilot Study

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Abstract

Background: Active substance use, food or housing insecurity, and criminal justice system involvement can disrupt HIV care for people living with HIV (PLWH) and opioid use disorder (OUD). These social determinants of health are not routinely captured in clinical settings.

Objective: We evaluated whether real-time reports of social and behavioral factors using a smartphone app could predict viral non-suppression and missed HIV care visits to inform future mobile health interventions.

Methods: We enrolled 59 participants from the AIDS Linked to the IntraVenous Experience (ALIVE) Study in Baltimore, Maryland into a 12-month sub-study between February 2017 and October 2018. Participants were eligible if they had OUD and had either a measured HIV RNA ?1000 copies/mL or a ?1 month lapse in antiretroviral therapy in the preceding 2 years. Participants received a smartphone and reported HIV medication adherence, drug use or injection, and several disruptive life events, including not having a place to sleep at night, skipping a meal due to lack of income, being stopped by police, being arrested, or experiencing violence on a weekly basis through a survey on a mobile health application. We described weekly survey completion and investigated which factors were associated with viral non-suppression (HIV RNA ?200) or a missed HIV care visit using logistic regression with generalized estimating equations adjusted for age, gender, smartphone comfort, and drug use.

Results: Participants were predominately male (61.0%), Black (89.8%), and a median of 53 years old. At baseline, 21.6% (N=8) were virally unsuppressed. Participants completed an average of 23.3 total surveys (SD: 16.3) and reported missing a dose of ART, using or injecting drugs, or experiencing any disruptive life events on an average of 13.1 (SD: 9.8) surveys over one year. Reporting use of any drugs (adjusted odds ratio [aOR]: 2.3, 95% Confidence Interval [CI]: 1.4-3.7), injecting drugs (aOR: 2.3, 95% CI: 1.3-3.9), and non-completion of all surveys (aOR: 1.6, 95% CI: 1.1-2.2) were associated with missing a scheduled HIV care visit over the subsequent 30 days. Missing ?2 antiretroviral medication doses within a one-week period was associated with HIV viral non-suppression (aOR: 3.7, 95% CI: 1.2-11.1) on laboratory tests drawn within the subsequent 30 days.

Conclusions: Mobile health applications can capture risk factors that predict viral non-suppression and missed clinic visits among PLWH who have OUD. Using mobile health tools to detect socio-behavioral factors that occur prior to treatment disengagement may facilitate early intervention by healthcare teams.

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Abstract

Background

Active substance use, food or housing insecurity, and criminal justice system involvement can disrupt HIV care for people living with HIV (PLWH) and opioid use disorder (OUD). These social determinants of health are not routinely captured in clinical settings. We evaluated whether real-time reports of social and behavioral factors using a smartphone app could predict viral non-suppression and missed HIV care visits to inform future mobile health interventions.

Methods

We enrolled 59 participants from the AIDS Linked to the IntraVenous Experience (ALIVE) Study in Baltimore, Maryland into a 12-month sub-study between February 2017 and October 2018. Participants were eligible if they had OUD and had either a measured HIV RNA ≥1000 copies/mL or a ≥1 month lapse in antiretroviral therapy in the preceding 2 years. Participants received a smartphone and reported HIV medication adherence, drug use or injection, and several disruptive life events, including not having a place to sleep at night, skipping a meal due to lack of income, being stopped by police, being arrested, or experiencing violence on a weekly basis through a survey on a mobile health application. We described weekly survey completion and investigated which factors were associated with viral non-suppression (HIV RNA ≥200) or a missed HIV care visit using logistic regression with generalized estimating equations adjusted for age, gender, smartphone comfort, and drug use.

Results

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Conclusion

Mobile health applications can capture risk factors that predict viral non-suppression and missed clinic visits among PLWH who have OUD. Using mobile health tools to detect socio-behavioral factors that occur prior to treatment disengagement may facilitate early intervention by healthcare teams.

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Conflicts of Interest: None.

Keywords: HIV, drug use, social determinants of health

Abbreviations

A-CHESS: Addiction Comprehensive Health Enhancement Support System

ALIVE: AIDS Linked to the IntraVenous Experience Study

ART: Antiretroviral therapy

HIV: Human Immunodeficiency Virus

PWUD: People who use drugs

RNA: Ribonucleic Acid

SD: Standard deviation

Introduction

In 2019, the US Department of Health and Human Services launched the Ending the HIV Epidemic in the U.S. initiative, establishing a goal to reduce new infections of HIV by 90% by the year 2030 [1]. Achieving this ambitious goal hinges on rapid linkage of newly diagnosed individuals to antiretroviral therapy (ART) and sustained HIV viral suppression to prevent transmission to others. People who use drugs (PWUD) living with HIV are among the most vulnerable to disruptions in care that threaten sustained viral suppression. Accordingly, active injection drug use and use of other substances, such as alcohol, are associated with inconsistent adherence to ART and viral non-suppression. [2–5].

The link between drug and alcohol use and viral non-suppression often relates to unmet needs broadly defined as social determinants of health [6]. For example, housing instability among PWUD has been linked to increased risk of both acquiring HIV and viral non-suppression across multiple studies [6]. In one study, people who acquired HIV by injecting drugs were more likely to be unstably housed [7]. Injecting drugs may also hinder improvements in housing situation and stability among people living with HIV [8], thereby threatening viral suppression.

Inadequate access to food is highly prevalent among PWUD [9,10] and has been associated with viral non-suppression [11], mortality [12], and engaging in behaviors that raise HIV transmission risk, such as receptive syringe sharing [13] and unprotected sexual intercourse [14]. The criminalization of drug use and social stigma of HIV further contribute to difficulties in engaging PWUD in both HIV and substance use disorder treatment [15] as well as to disruptions in care due to arrest or incarceration [16,17]. The link between social determinants of health and patients' capacity to engage and sustain in HIV care illustrates a need for innovative strategies that provide timely support to address the root causes of care disruption and viral non-suppression.

Mobile health (mHealth) is defined broadly by the World Health Organization as, "mobile and wireless technologies to support the achievement of health objectives" [18]. mHealth tools can

provide a platform that facilitates real-time detection and the provision of timely assistance when events that could disrupt care engagement occur. Further, information captured through mHealth applications could detect early warning signs of care disengagement, such as missed ART doses or increases in drug use. These technologies may be particularly well-suited to augment existing patient-centered, comprehensive models of HIV care that are enabled by federal Ryan White funding in the U.S. [19], as these care models already feature medical case management, food pantries, support to obtain housing, and other services to address social determinants of health. In the present study, we explored the potential of a smartphone application to detect disruptive life events and early warning signs of HIV care disengagement over a one-year period among 59 PWUD living with HIV. Using a weekly survey within a smartphone application designed to support substance use disorder recovery, we assessed how often PWUD used the smartphone application and reported experiencing disruptive life events. Through subsequent linkage with electronic health record data, we assessed whether these disruptive life events were associated with two outcomes representing care disengagement: viral non-suppression and missed HIV care visits.

Methods

Participants, Recruitment, and Follow-Up

Participants for this study came from the AIDS Linked to the IntraVenous Experience (ALIVE) study, a prospective cohort study of people who inject drugs in Baltimore, Maryland that has been described previously [20]. A total of 5,506 individuals have been enrolled since the study began in 1988. To enroll in the ALIVE study, participants must be aged 18 years or older and have a history of injection drug use. Participants are tested for HIV at enrollment. Follow-up is ongoing and involves twice-yearly visits to the ALIVE clinic where participants complete surveys about health history in the past 6 months and repeat HIV testing.

The present analysis includes 59 ALIVE study participants recruited through flyers posted in a local

HIV care clinic and within the ALIVE study office. All met the following eligibility criteria: 1) ever had an opioid use disorder, 2) used a non-prescribed opioid in the past year, and 3) not treated with ART for ≥1 month in the past 2 years or had an HIV RNA viral load of ≥1000 copies/mL in the past 2 years, 4) a patient of the local HIV clinic from which participants were recruited, and 5) a participant of the ALIVE study. Participant eligibility was verified through review of electronic health records.

Eligible participants who provided informed consent to participate in the sub-study received a smartphone with an unlimited voice and data plan and underwent a brief training with a study coordinator on using the study mHealth app. Participants completed an interviewer-administered baseline survey and follow-up surveys every 3 months for a one-year period. They were compensated $20 per survey plus an additional $50 for completing all five study surveys. The study team received HIV viral load testing results from the electronic health record at the local HIV clinic where recruitment was conducted and from routine semi-annual testing performed as part of ALIVE study follow-up. The date of all scheduled HIV care visits at the local HIV clinic and whether visits were missed or attended was also collected. Enrollment and follow-up occurred during 2017-2018. This study was approved by the Institutional Review Boards at the University of Wisconsin-Madison and Johns Hopkins University.

The A-CHESS mHealth Application

The mHealth system used in this study, the Addiction-Comprehensive Health Enhancement Support System (A-CHESS), was designed to support recovery from alcohol use disorder and found to reduce drinking in a prior study of people with alcohol use disorder [21]. A-CHESS has since been adapted for several other risk groups, including those living with opioid use disorder [22,23]. The theoretical framework supporting A-CHESS is Self-Determination Theory [24], which emphasizes that adaptive functioning to manage health conditions is improved by meeting three needs:

competence (i.e., the ability to cope with challenges), social relatedness (i.e., having meaningful relationships and a feeling of connection), and autonomy (i.e., a sense of control over behavior and goals). A-CHESS is therefore organized around these three pillars. Competence is supported by an extensive resource library containing podcasts, information, and other resources to support recovery. An in-app discussion board and private messaging function support relatedness by allowing app users to connect with one another and with case managers or providers who also have accounts on the app. A weekly self-monitoring survey and the ability to create and save personal goals within the app provide opportunities to build autonomy. Participants receive notifications to complete the self-monitoring survey on a weekly basis. For this study, the weekly self-monitoring survey was adapted to investigate potentially disruptive events that could threaten sustained engagement in HIV care, such as being arrested or not having a place to live, as well as events that may signal or raise risk of HIV care disengagement, such as missed ART doses and drug use (further described in Measures). Participants were invited to use A-CHESS on their study-provided cellphone for 12 months.

Measures

At the study enrollment visit, participants completed a survey administered by study staff after consenting to participate in the study. They reported their HIV diagnosis date and whether they were currently using ART. Regarding drug use, participants reported whether they had used any illegal/street drugs (including marijuana) or used any medications not as prescribed in the past 30 days, what drugs they used, and whether they were currently taking any medications for opioid use disorder (including methadone, buprenorphine, or naltrexone). Participants also reported whether they had ever been diagnosed with any mental health conditions, including anxiety, depression, bipolar disorder, attention deficit hyperactivity disorder, obsessive compulsive disorder, panic disorder, or post-traumatic stress disorder. Participants reported their comfort level using a smartphone on a numeric scale of 1 (not at all comfortable) to 5 (very comfortable). Finally,

participants reported sociodemographic characteristics, including age, gender, race, ethnicity, education, and employment.

The two primary outcomes of the study were abstracted through a review of electronic health records and ALIVE study data available for each participant during the one-year follow-up period. These included viral non-suppression, defined by the Centers for Disease Control and Prevention as an HIV viral load of ≥200 copies/mL (vs. viral load of <200 copies/mL) [25] and missing an HIV care visit, defined as missing any scheduled visit to the local HIV care clinic affiliated with the study (vs. attending the visit). The HIV viral load at baseline was considered the closest HIV measurement to a participant's baseline survey within the period of one year before to seven days after study enrollment. Electronic health records were also used to characterize baseline CD4+ count defined as the closest CD4 measurement to a participant's baseline survey within the 1 year before to 60 days after the baseline date. For the missed visit outcome, a total of 841 HIV care visits scheduled with a medical provider, nurse, case manager, or mental health provider were included in the analysis. The primary outcome was whether a scheduled visit was missed versus attended. A total of 147 HIV care visits that were cancelled before the appointment occurred were excluded from analyses.

The weekly self-monitoring survey included questions about the number of days ART was not taken, any drug use (defined as by combining separate questions on use of heroin, any other opioids [including oxycodone, morphine, fentanyl, etc.], cocaine, methamphetamine, or sedatives [including Valium, Ativan or Xanax]), any injection drug use, and several potentially disruptive life events over the past seven days. Potentially disruptive life events included not having a place to sleep, skipping a meal because of not having enough income, being stopped by police, being put in jail, and being robbed or beat up. Responses to questions on the weekly self-monitoring survey were used to form several binary indicator variables summarizing whether events of interest were reported on any weekly survey completed in the 30 days prior to having a viral load measurement and separately, in the 30 days prior to a scheduled HIV care visit. Binary variables for non-completion of all weekly

surveys in the 30 days prior to each outcome and for reporting any significant event (i.e., missed ART dose, any drug use, injecting drugs, or any disruptive life event) in the 30 days prior to each outcome were also created. These indicators were analyzed as the primary independent variables for the study. A-CHESS system use was summarized as the average number of days A-CHESS was used and average number of weekly surveys completed per participant over the entire one-year study period and per study month.

Analysis

Descriptive characteristics of the sample at baseline were calculated and compared between those who had at least one HIV viral load ≥200 copies/mL (vs. those for whom all HIV test results across the one-year study period indicated viral suppression). These characteristics were also compared for those who missed ≥50% of their HIV care visits (vs. <50%). Engagement with the A-CHESS smartphone application was described in the total sample and by the primary outcomes. To characterize whether reporting missed ART doses, any drug use, injecting drugs, or experiencing a disruptive life event were associated with viral non-suppression or a missed HIV care visit, logistic regression with generalized estimating equations accounting for repeated outcome measurements for each participant were used to estimate odds ratios with 95% confidence intervals, as participants could have multiple HIV viral loads taken or HIV care visits scheduled over the one-year follow-up period. Unadjusted models and models adjusted for several confounders selected *a priori* were computed. Confounders included in adjusted models were sociodemographic characteristics (age, race, ethnicity, gender), comfort using a smartphone (treated as a continuous variable with a range of 1 to 5), and whether the participant had used any drugs in the past 30 days, all of which were reported at study enrollment. In a sensitivity analysis, models were run with an alternate definition of HIV viral non-suppression, ≥1,000 copies/mL, as this matched one of the eligibility criteria for the study and was used to define virological failure in a prior, foundational study of HIV transmission

[26].

Results

Participant characteristics at baseline

A total of 59 participants enrolled in the one-year study (Table 1). At baseline, participants were a mean age of 53 years and predominantly male (61%), black race (90%), and non-Hispanic ethnicity (91%). Approximately 53% had less than a high school education and only 5% were employed at the time of the study. In the month before enrollment, 83% had used any drugs, 71% used opioids, 48% used stimulants, and 27% had injected drugs. While nearly all (93%) reported currently taking ART, 16% were virally non-suppressed (defined as having a viral load of ≥1,000 copies/mL at baseline) and 20% had a CD4+ count <200 cells/mm^3. Participants had been living with HIV for a mean of 19 years prior to study enrollment.

Table 1. Descriptive characteristics at baseline and A-CHESS engagement in a sample of people living with HIV and OUD

Characteristic	Total	HIV Viral Suppression		Missed Visits	
	N (%)	*≥1 Test ≥200 copies/mL, N (%)*	*All Tests <200 copies/mL, N (%)*	*Missed ≥50% Visits, N (%)*	*Missed <50% Visits, N (%)*
Total N	59	25	27	23	33
Median age (IQR), years	53 (11)	53 (9.0)	53 (12.5)	51 (10.0)	53 (11.1)
Female gender (vs. male)	23 (39.0)	11 (44.0)	10 (37.0)	7 (30.4)	15 (45.5)
Black or African American Race (vs. another race)	53 (89.8)	25 (100)	24 (88.9)	21 (91.3)	29 (87.9)
Hispanic or Latinx (vs. Non-Hispanic)	5 (8.5)	0 (0.0)	4 (14.8)	2 (8.7)	3 (9.1)
Less than high school education (vs. high school or more)	31 (52.5)	12 (48.0)	14 (51.9)	12 (52.2)	17 (51.5)
Employed (vs. unemployed)	3 (5.1)	1 (4.0)	2 (7.4)	3 (13.0)	0 (0.0)
Comfort using a smart phone, Mean (SD)	3.8 (1.3)	3.8 (1.4)	3.7 (1.3)	3.8 (1.3)	3.9 (1.3)
Any mental health concerns (vs. none)	40 (67.8)	15 (60.0)	20 (74.1)	15 (65.2)	25 (75.8)
Used drugs in past 30 days (vs. none)	49 (83.1)	19 (76.0)	25 (92.6)	20 (87.0)	27 (81.8)
Used opioids in past 30 days	42 (71.2)	16 (64.0)	22 (81.5)	16 (69.6)	25 (75.8)

(vs. none)					
Used stimulants in past 30 days (vs. none)	28 (47.5)	11 (44.0)	15 (55.6)	13 (56.5)	15 (45.5)
Injected drugs in past month (vs. not)	16 (27.1)	6 (24.0)	7 (25.9)	7 (30.4)	8 (24.2)
Taking a medication for opioid use disorder (vs. not)	38 (64.4)	16 (64.0)	16 (59.3)	19 (82.6)*	16 (48.4)*
Years living with HIV, Mean (SD)	19.4 (8.7)	19.1 (7.5)	20.0 (9.2)	17.8 (7.2)	20.4 (9.1)
Currently taking ART (vs. not)	55 (93.2)	26 (96.3)	23 (92.0)	22 (95.7)	30 (90.9)
HIV RNA ≥1,000 copies/mL[c] (vs. <1,000)	6 (16.2)	5 (29.4)	1 (6.3)	2 (14.2)	4 (19.0)
CD4+ count <200 cells/mm^3[b] (vs. ≤200)	10 (20.0)	8 (36.4)	1 (4.5)	8 (40.0)	1 (3.7)

[a]The small sample size and uneven distribution of responses in the sample precluded statistical testing.
[b]n=50 participants had an available CD4 count at baseline.
[c]n=37 participants had an available HIV viral load result at baseline
*Statistically significant difference (p=0.009); p>0.20 for all other comparisons

Of the 59 participants, 52 individuals had at least one HIV viral load test during follow-up, comprising 237 total viral load tests. Nearly half of participants (48%, n=25) had at least one detectable viral load of ≥200 copies/mL during the follow-up period. Regarding missed HIV care visits, 56 participants had an HIV care visit scheduled during the follow-up period, comprising 841 total scheduled visits. A total of 41% of participants missed at least half of their HIV care visits during the study period.

The modest sample size limited our ability to test for differences in baseline characteristics between those who were virally non-suppressed at least once over the follow-up period or who missed over half of their HIV care visits, as shown in Table 1. The only statistically significant association indicated that taking medication for an opioid use disorder was positively associated with missing at least half of scheduled HIV care visits (p=0.009).

A-CHESS engagement and weekly reports of missed ART doses, drug use, and disruptive life events

Over the 1-year follow-up period, participants used ACHESS an average of 119.4 total days

(standard deviation [SD]: 82.8) and on an average of 11.5 days per month (SD: 4.4 days). The weekly survey was completed an average of 23.3 times (SD: 16.3) per participant across the follow-up period, leaving a total of 1,353 weekly surveys available for analysis (Table 2). In total, 46% of weekly surveys included a report of missed ART doses, drug use, and/or a disruptive life event. Missing a dose of ART was reported on 25% of surveys, an average of 8.5 (SD: 7.1) times per participant across the study period. Using any drugs was reported an average of 9.5 (SD: 9.3) times per participant across the study period and injecting drugs was reported 5.8 (SD: 8.2) times per participant. Disruptive life events included: skipping a meal (mean [SD] times reported during follow-up: 6.6 [6.5]), not having a place to sleep (mean [SD]: 2.7 [3.4]), being put in jail (mean [SD]: 1.5 [0.6]), and being robbed or beat up (mean [SD]: 1.6 [0.9]).

Table 2. Events reported on weekly A-CHESS weekly surveys

	Total # of weekly surveys (% of total)	Mean # of weekly surveys completed per participant (Standard Deviation)
Total number of weekly surveys completed	1353 (100)	23.3 (16.3)
Reported any missed ART, drug use, or disruptive life event	627 (46.3)	13.1 (9.9)
1 or more missed ART doses	341 (25.2)	8.5 (7.1)
2 or more missed ART doses	190 (14.0)	5.9 (6.1)
Any drug use	417 (30.8)	9.5 (9.3)
Injected drugs	116 (8.6)	5.8 (8.2)
Did not have a place to sleep at night	27 (2.0)	2.7 (3.4)
Skipped a meal because I didn't have enough money	131 (9.7)	6.6 (6.5)
Was stopped by police	22 (1.6)	1.8 (1.2)
Was put in jail	9 (0.7)	1.5 (0.6)
Was robbed or beat up	13 (1.0)	1.6 (0.9)

Supplemental Table 1 shows the association of A-CHESS utilization frequency and weekly survey completion during follow-up with being virally non-suppressed at least once over the follow-up period or who missing over half of their HIV care visits. These comparisons indicate that more weekly surveys were completed by those who did not have any viral loads ≥200 copies/mL (p=0.01) and who did not miss any HIV care visits (p=0.005) and that those who did not miss any HIV care

visits during follow-up tended to use A-CHESS more often (p=0.03).

Association of missed ART, drug use, and disruptive life events reported through A-CHESS with missed visits and viral non-suppression

In bivariable and adjusted analyses, injecting drugs, any drug use, and not completing any weekly surveys in the prior month were associated with missing an HIV care visit in the subsequent 30 days (Table 3). Specifically, injecting drugs was associated with a 2.3-fold higher adjusted odds (95% CI: 1.3-3.9) and using any drugs was associated at a similar magnitude with missing an HIV care visit after adjustment for age, comfort using a smartphone, gender, and any drug use at baseline. Not completing the weekly survey (vs. completing at least one weekly survey) was associated with a 57% higher odds of missing an HIV care visit in the following 30 days (adjusted OR [95% CI]: 1.6 [1.1-2.2]).

Table 3. Association of reporting missed ART doses, drug use, and disruptive life events in the prior 30 days with missing an HIV care visit

Events reported in the month prior to scheduled HIV care visit[a]	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[b]
Any missed ART, drug use, or disruptive life event	1.20 (0.80-1.81)	1.25 (0.81-1.93)
1 or more missed ART doses	0.91 (0.61-1.35)	0.89 (0.57-1.39)
2 or more missed ART doses	1.22 (0.70-2.15)	1.30 (0.69-2.43)
Any drug use	2.07 (1.28-3.35)	2.27 (1.41-3.66)
Injected drugs	2.11 (1.24-3.59)	2.26 (1.30-3.91)
Did not have a place to sleep at night	1.87 (0.38-9.27)	1.76 (0.28-11.14)
Skipped a meal due to not enough money	0.76 (0.36-1.60)	0.81 (0.37-1.74)
Stopped by police	1.07 (0.45-2.54)	1.11 (0.42-2.97)
No weekly surveys completed in past 30 days	1.42 (1.00-2.02)	1.57 (1.10-2.22)

[a]Odds ratios are reported relative to a referent group that completed at least one weekly survey in the 30 days prior to a scheduled HIV care visit but did not indicate experiencing the disruptive life event.

[b]Adjusted for age, gender, comfort using a smartphone (score: 1 [not at all comfortable] to 5 [very comfortable]), and any drug use in the past 30 days, all of which were reported at study enrollment.

In both unadjusted and adjusted analyses, missing 2 or more doses of ART was associated with having a non-suppressed viral load in the following 30 days (adjusted OR [95% CI]: 3.7 [1.2-11.1],

Table 4). These associations were similar in a sensitivity analysis in which the outcome was defined as a viral load of load ≥1,000 (Supplemental Table 2). Notably, we were unable to adjust for race or ethnicity given the predominantly black and non-Hispanic racial/ethnic makeup of the sample (90% black and 9% Hispanic). Further, because being put in jail and robbed or beat up were each reported on few surveys (<15 surveys each), we were unable to analyze their relationship with the primary outcomes of interest.

Table 4. Association of reporting missed ART doses, drug use, and disruptive life events in the prior 30 days with having HIV viral nonsuppression (viral load ≥200 copies/mL)

Events reported in the month prior to viral load measurement[a]	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[b]
Any missed ART, drug use, or disruptive life event	1.30 (0.72-2.33)	1.28 (0.68-2.44)
1 or more missed ART doses	1.96 (0.88-4.35)	1.92 (0.76-4.76)
2 or more missed ART doses	4.00 (1.61-10.00)	3.70 (1.23-11.11)
Any drug use	0.93 (0.46-1.85)	0.92 (0.44-1.92)
Injected drugs	0.79 (0.22-2.86)	0.74 (0.19-2.78)
Did not have a place to sleep at night	2.38 (0.56-10.00)	2.44 (0.54-11.11)
Skipped a meal due to not enough money	0.64 (0.25-1.67)	0.6 (0.22-1.64)
Stopped by police	1.72 (0.34-8.33)	1.67 (0.32-9.09)
No weekly surveys completed in past 30 days	0.94 (0.53-1.69)	0.87 (0.46-1.64)

[a]Odds ratios are reported relative to a referent group that completed at least one weekly survey in the 30 days prior to a viral load test but did not indicate experiencing the disruptive life event.

[b]Adjusted for age, gender, comfort using a smartphone (score: 1 [not at all comfortable] to 5 [very comfortable]), and any drug use in the past 30 days, all of which were reported at study enrollment.

Discussion

This study is a proof-of-concept demonstrating the utility and feasibility of using an mHealth system to capture time-varying threats to HIV viral suppression and care engagement among people living with HIV and opioid use disorder. Our system focused on detecting early warning signs of HIV care disengagement and disruptive events that fall within the realm of social determinants of health known to impact the health of PWUD [6]. Over a one-year period, we captured >600 reports of

events that could be disruptive to HIV care and/or be early warning signs of care disengagement. Using or injecting drugs and reporting missed doses of ART were associated with elevated likelihood to miss an HIV care visit or be virally non-suppressed during follow-up, respectively. Not completing any of the weekly check-in surveys was also associated with missing an HIV care visit. While our study lacked the statistical power needed to assess whether disruptive life events reported less frequently, including housing insecurity, experiencing violence, and being arrested, were associated with poor outcomes, our results support the need to conduct larger studies of time-varying threats to care engagement in the future. An mHealth system like ours could be utilized in HIV care settings to assist case managers and social workers in proactively detecting and addressing these threats.

Our sample of PWUD answered an average of 23 of 52 total weekly surveys available to them during the one-year follow-up period, a response rate of 44%. Despite that participants were not remunerated for completing weekly surveys, as they were operationalized as a self-assessment tool to enhance self-determined motivation as part of the A-CHESS app, this response rate is similar to several studies among people living with HIV [27]. Nonetheless, the utility of the weekly survey as an informative tool for clinical action may require a higher response rate. Thus, future studies may consider strategies such as incentivizing weekly surveys or sending surveys at a time most likely to get a response [28].

At the same time, our findings suggest that missing up to four consecutive surveys may be a helpful threshold to prompt a case manager or social worker to proactively reach out to a patient about any difficulties they may be experiencing and ensure any needs are met through appropriate referrals or direct provision of support. This conclusion is supported by considering multiple of our findings together, including our modest response rate, finding that not answering at least one survey over a four-week period was associated with missing an HIV care visit, and finding that those who did not experience viral non-suppression or missed visits tended to engage with the app more frequently. A

focus on monthly, rather than weekly, engagement with A-CHESS may also help to reduce alert fatigue, a phenomenon wherein people using technology become desensitized after receiving many alerts or notifications, among both staff and app users [29–32] and balance the extra staff time required to access A-CHESS and follow up with disengaged participants. Indeed, another ongoing study of A-CHESS in the substance use treatment setting suggests that staff time is a major barrier to utilizing a clinician dashboard feature added to A-CHESS [33], which provides an easy to interpret interface to monitor patient survey results and app engagement. Prior studies of A-CHESS also suggest that providing dedicated support to implement A-CHESS within a healthcare organization using strategies such as coaching and process improvement models to ensure clinicians have dedicated time, technical assistance, and resources to integrate this new clinical tool into existing workflows [34,35]. Our finding that using and injecting drugs were associated with subsequently missing HIV care visits further suggests that collecting additional information about the context of drug use may assist clinicians in aiding patients with identifying protective factors and social supports available to them at the time when drug use or craving occurs [36].

The need for novel and effective mHealth interventions is underscored by findings from several demonstration projects that were part of HRSA's Special Projects of National Significance focused on social media and mHealth for supporting retention in HIV care [37]. This work identified three promising foci for mHealth tools, including (1) managing HIV care; (2) fostering feelings of support and personal connectedness; and (3) helping alleviate negative feelings about status and mitigating HIV-related stigma [38]. A-CHESS has the capacity to meet all three of these needs. Through its theoretical foundations in self-determination theory [24], A-CHESS facilitates patient-provider connection and support through messaging functions and a clinician dashboard that can highlight weekly self-monitoring survey results and peer connections through a discussion board, targeted resources, and other key features.

Limitations

The modest sample size of the study did not allow us to comprehensively assess or adjust for a broad set of confounders. Thus, we presented both unadjusted and adjusted results that could account for key confounders we identified *a priori*, including sociodemographic characteristics, comfort level with using a smartphone, and recent drug use at baseline. The overall conclusions drawn from the results were consistent in adjusted and unadjusted models. Additionally, several of the disruptive life events of interest (i.e., housing instability, food insecurity, and law enforcement interaction) were reported infrequently over the follow-up period, which did not allow us to examine their association with missing an HIV care visit or viral non-suppression. As these are known contributors to disengagement with HIV care, they will be important to study in future, larger studies. Our results suggest that, when experienced, our smartphone application platform was able to capture at least some of these events on a weekly basis. Finally, we were unable to include cancelled HIV care visits and it was impossible to determine if or when the visit was rescheduled. Further analysis of patients who cancel a visit and do not return to care are warranted.

Conclusions

A-CHESS is a promising tool for capturing time-varying threats to engagement in HIV care among PWUD. Future research should examine whether receiving tailored support based on disruptive life events reported in A-CHESS is effective in reducing viral non-suppression and HIV care disengagement and evaluate how to integrate A-CHESS within the HIV medical home setting.

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Supplementary Files

Multimedia Appendixes

Supplementary tables.
URL: http://asset.jmir.pub/assets/e8dbb10cf9a95a2231897729723cd44e.docx