International Journal of Drug Policy 72 (2019) 129–137

Contents lists available at ScienceDirect

International Journal of Drug Policy

journal homepage: www.elsevier.com/locate/drugpo

Hepatitis C treatment outcomes among homeless-experienced individuals at a community health centre in Boston

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ARTICLE INFO

Keywords:
Homelessness
Hepatitis C
Injection drug user

ABSTRACT

Background: Hepatitis C virus (HCV) infection prevalence is high among adults who experience homelessness but data on HCV treatment outcomes are limited in this population. We examined HCV treatment engagement and outcomes in a cohort of homeless-experienced adults treated through an innovative community-based primary care program in Boston, Massachusetts, USA.

Methods: We conducted a retrospective chart review of individuals referred for HCV treatment at Boston Health Care for the Homeless Program (BHCHP) from January 2014 to March 2017. We assessed HCV treatment initiation, treatment completion, sustained virologic response (SVR), and reinfection rates. We conducted univariate and multivariable logistic regression analyses to examine the predictors of these outcomes.

Results: Of 510 referred for HCV treatment, 210 (41.1%) did not initiate treatment, principally because of being lost to follow-up (N = 93) or having superseding social issues (N = 49). Of 300 who initiated treatment, 80% were male, 52.3% were non-white, and 29% were homeless. Over half (58.6%) had a history of opioid use disorder (OUD). Twenty percent had cirrhosis. Treatment was completed by 285 (95.0%) individuals, and 255 (85.0%) achieved SVR. In multivariable analyses, individuals with bipolar disorder (OR 0.38, 95% CI 0.15 – 0.99), treated (OR 0.36, 95% CI 0.14 – 0.96) or untreated (OR 0.18, 95% CI 0.05 – 0.57) OUD, or on-treatment insurance change (OR 0.16, 95% CI 0.04 – 0.67) were less likely to achieve SVR, while individuals living with HIV (OR 10.43, 95% CI 1.33–81.96) were more likely to achieve SVR. Among 126 individuals with post-SVR follow-up data, 27 reinfections were identified during 206 person-years of follow up (rate 13.1 per 100 person-years).

Conclusion: Homeless-experienced individuals initiating HCV treatment in a community-based program achieved high rates of treatment completion and SVR, but a large proportion did not initiate treatment. Individuals with OUD experienced lower but still substantial rates of cure. Treatment strategies targeting homeless-experienced people should focus on improving initial engagement and minimizing reinfection risk following treatment.

Background

Hepatitis C virus (HCV) infection is highly prevalent in homeless populations, with global estimates ranging from 3.9 to 36% (Beijer, Wolf, & Fazel, 2012), and estimates among homeless health care programs in the United States ranging from 18 to 48% (Strehlow et al., 2012). Homeless individuals who inject drugs appear to have an especially high burden of HCV, with reported prevalence ranging from 55 to 81% (Strehlow et al., 2012). The availability of short-duration, highly effective, and well-tolerated direct-acting antiviral (DAA) therapies for HCV presents the opportunity to improve access and successful outcomes for marginalized populations, such as people who inject drugs (PWIDs) and homeless individuals. The successful implementation of DAA treatment for PWIDs has now been well described (Hajarizadeh et al., 2018). Additionally, community-based HCV treatment by primary care providers has emerged as an effective strategy to reach marginalized populations (Arora et al., 2011; Kattakuzhy et al., 2017; Hodges, Reyes, Campbell, Klein, & Wurcel, 2018). Despite this progress, evidence of successful HCV treatment implementation in currently and formerly homeless individuals remains limited and post-treatment

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https://doi.org/10.1016/j.drugpo.2019.03.017

reinfection rates have not been described.

In a prior study of the first 64 patients treated by the Boston Health Care for the Homeless Program (BHCHP) HCV program 97% experienced sustained virologic response (SVR) (Barocas et al., 2017). In this follow-up study, our objective was to assess HCV treatment initiation, treatment completion, sustained virologic response (SVR), and reinfection rates in a larger cohort of homeless-experienced individuals referred to the BHCHP HCV treatment team. Our findings have the potential to inform future efforts at treating similarly marginalized groups of individuals that experience a high burden of HCV infection.

Methods

Participants and setting

We conducted a retrospective chart review of all individuals who were referred to the Boston Health Care for the Homeless Program (BHCHP) HCV treatment team between January 2014 and March 2017.

BHCHP is a Federally-Qualified Health Centre (FQHC) that provides integrated primary care services via a patient-centered medical home approach to more than 11,000 individuals annually in the Boston area. The BHCHP HCV treatment team was founded in January 2014 and consists of a non-clinician care coordinator (1.0 full-time equivalent [FTE]), a registered nurse (0.5 FTE), a primary care nurse practitioner who also serves as team director (0.2 FTE), and 2 primary care physicians (each 0.05 FTE).

There was no pre-screening or eligibility criteria to be referred to the HCV team apart from an established HCV diagnosis. Referral occurred through various pathways, including from other providers at BHCHP, direct linkage from BHCHP's HIV and STI screening program, or patient self-referral. Patient outreach and education sessions at BHCHP outpatient and shelter-based clinics promoted awareness of HCV and the availability of treatment. Individuals were not required to receive primary care or other health services at BHCHP to be linked to the BHCHP HCV treatment team.

The HCV treatment team followed a standardized intake assessment and treatment protocol developed by the team director. New patients first met with the HCV team nurse for lab evaluation with serum testing that confirmed chronic HCV infection, initial education, and assessment of treatment readiness. In a subsequent visit, a team clinician completed a baseline HCV and liver health assessment, recommended the appropriate treatment regimen, and confirmed the plan for management. Initial hepatic fibrosis assessment was conducted principally using the FIB-4 index, which is calculated based on age, platelet count, and transaminase levels (Vallet-Pichard et al., 2007). Liver elastography was available at a local hospital in the case of indeterminate or advanced FIB-4 results. Individuals with cirrhosis were referred for appropriate screening for liver cancer and esophageal varices, though this was not required to be completed before treatment initiation.

All individuals who attended an initial nurse appointment were considered linked to the HCV team. The team offered treatment to those with confirmed chronic HCV infection regardless of fibrosis stage. Reasons for not initiating treatment included nonadherence to subsequent appointments, identification of spontaneous clearance, linkage to HCV treatment at another location, having a more pressing medical or social need at the time of evaluation identified by the patient and/or HCV team provider, or death. Abstinence from drugs and/or alcohol was not required to engage in HCV treatment. HCV regimen decisions were determined based on guidelines from the American Association for the Study of Liver Diseases-Infectious Disease Society of America (AASLD-IDSA) ("Recommendations for testing, managing, and treating hepatitis C". n.d.). Approval of DAAs, guideline recommendations, and payer preferences all evolved throughout the study period, and these factors influenced the selection of regimens as well. The BHCHP team treated individuals with decompensated cirrhosis with support from a local hepatology specialist.

Adherence support for patients on treatment was designed to be dynamic and responsive to the needs and challenges of the homeless and unstably-housed population. Adherence support, at its lowest intensity, included monthly visits and weekly calls from the HCV care coordinator. More intensive support options, including medication storage at the clinic with weekly nurse visits for pillbox assistance or daily directly-observed therapy (DOT) administered at the clinic, were available for individuals who wished to utilize them. The method of support was determined in conjunction with the patient and there was no randomization of any treatment procedures. Those who were started on treatment were asked to return for HCV lab testing at 4 weeks, at the end of treatment (8–24 weeks, depending on the regimen), and at 12 weeks after treatment completion to assess for sustained virologic response (SVR). Additional follow-up evaluation was attempted one year after SVR, or earlier based on risk factors for reinfection.

Chart abstraction procedure

Research team members conducted manual chart reviews of the BHCHP electronic health records of all adult patients evaluated by the BHCHP HCV treatment team between January 2014 to March 2017. Researchers used a standardized approach and abstracted data into an electronic form in Microsoft Excel. All relevant notes and lab results from the initial evaluation through treatment completion and follow-up were reviewed. The expert clinical member of the study team (MEB) reviewed a random selection of abstractors' charts to ensure data were collected in a consistent and accurate manner. Discrepancies were resolved through team-based discussion and data were recoded as necessary.

Baseline variables

Baseline variables included demographic characteristics, comorbid conditions, and HCV-related parameters.

Sociodemographic characteristics

We recorded age, gender, race/ethnicity, housing status (housed, homeless, residential/transitional treatment, or other/unknown), veteran status, prior six-month history of incarceration, and location of primary care provider (at BHCHP, outside BHCHP, or other/unknown). Individuals were considered homeless if the medical record indicated a usual nighttime residence of shelter, street, motel, or doubled-up (One hundred eleventh Congress of the United States of America. Sec. 1003, 2009; Baggett et al., 2018; Hwang et al., 2008)

Comorbid conditions

We recorded the presence of medical, mental health, and substance use comorbidities based on ICD-10 codes present in the patient's problem list at the baseline assessment. Medical conditions included HIV infection, hypertension, diabetes mellitus, hyperlipidemia, liver cancer, and chronic kidney disease. Mental health disorders included major depressive disorder, generalized anxiety disorder, post-traumatic stress disorder, psychotic disorders (schizophrenia, delusional disorder, and schizoaffective disorder), and bipolar disorder. Substance use disorders recorded were alcohol use disorder (AUD) and opioid use disorder (OUD). We distinguished which individuals were on medication for opioid use disorder (MOUD) and the type of medication used (methadone, buprenorphine, or naltrexone). A history of a recent opioid overdose within the prior six months was noted, if present.

HCV-related parameters

We recorded patient-identified risk factors for HCV acquisition, including injection drug use, sexual exposure, iatrogenic exposure, casual exposure (e.g. sharing personal items possibly contaminated with blood), or unknown. We also noted HCV genotype and baseline quantitative HCV ribonucleic acid (RNA) levels (i.e. "viral load"). We

recorded the baseline Metavir stage of liver fibrosis (F0-F4) and the method used to estimate fibrosis stage (FIB-4, elastography, serum biomarkers, or clinical diagnosis). Individuals whose only fibrosis assessment was a FIB-4 < 1.45 were staged as F0-F1 in accordance with the measure's interpretation (Vallet-Pichard et al., 2007).

On-treatment variables

On treatment variables included insurance payer variables, method of adherence support, and on-treatment events experienced by the patient.

Payer factors

We recorded the insurance type utilized to obtain HCV medication, including Medicare, Medicaid, and private insurance, and the type of pharmacy utilized to obtain medication (mail-order pharmacy, BHCHP's co-located 340B pharmacy, commercial pharmacy).

Adherence support model

We recorded the model employed to support medication adherence as described above. If more than one model was used, the predominant type was selected.

On treatment experiences

We recorded on-treatment experience of incarceration, insurance interruption or change, address change, hospitalization, substance use, and missed doses of HCV medication (none, < 7 days, or ≥7 days or unknown) if they were documented in the charts reviewed. These events could have been reported by the individual or described by the note writer.

Treatment process measures

We descriptively assessed each step of the HCV treatment cascade, including the number of individuals who started or did not start treatment, the percentage of treatment initiators who completed treatment or were lost to follow-up, and the percentage of treatment completers who returned for SVR assessment.

Treatment outcomes

The primary outcome was SVR, defined as an HCV RNA ≤ 15 IU/mL at least 12 weeks after treatment completion. The secondary outcome was HCV reinfection following treatment completion, defined as having an HCV RNA > 15 IU/mL at any point after SVR was confirmed or a detectable HCV RNA at SVR assessment with a genotype different than the pre-treatment genotype.

Data analysis

We descriptively examined the baseline characteristics of patients using means and standard deviations for continuous variables and counts and percentages for categorical variables. We compared the baseline characteristics of patients who started HCV treatment with patients for whom HCV treatment was deferred using t tests for continuous variables and Fisher exact tests for categorical variables. Among those who initiated treatment, we calculated the percentage who completed treatment and the percentage of treatment completers who returned for SVR testing to gauge attainment of these process measures.

To assess the primary treatment outcome, we calculated SVR using the intention to treat (ITT) principle where all participants who started treatment were included in the denominator regardless of whether they were lost to follow-up. Those lost to follow-up were considered not to have achieved SVR. In a sensitivity analysis, we reassessed the percentage who achieved SVR using a modified ITT (mITT) approach where participants completing treatment but lost to follow-up for SVR assessment were excluded from the denominator (Hajarizadeh et al., 2018).

We used t tests and Fisher exact tests to examine the unadjusted associations between all baseline and on-treatment predictor variables and the outcome of achieving SVR. We then pursued multivariable modeling to identify the most important predictors of SVR. Variables were selected for multivariable modeling by using high-performance multi-thread logistic regression analysis with stepwise competitive variable selection to achieve an optimal Akaike Information Criterion (AIC), constrained to a maximum of 5 effects to avoid model overfitting given the limited number of individuals who did not achieve SVR. Adjusted odds ratios were then computed by constructing a multivariable logistic regression model containing the 5 effects identified in the high-performance selection procedure. Missed medication doses were not considered for entry in the multivariable model because it was conceived of as a final common pathway (or mediating variable) for treatment failure due to a variety of upstream factors. In an exploratory analysis, we examined this assumption by assessing whether significant predictors of SVR from the multivariable model were also significant predictors of medication adherence.

For the secondary outcome of HCV reinfection, we calculated the reinfection rate among patients who achieved SVR according to the method of Martinello et al. (2017), where the number of reinfections was divided by the person-years of follow-up after treatment completion. With this method, reinfected patients were assumed to have acquired their reinfection at the midpoint between treatment completion and the date of the positive HCV RNA test confirming reinfection. In sensitivity analyses, we calculated the reinfection rate two other ways, using date of expected SVR or date of actual SVR assessment as the starting point, and the reinfection date defined as the time of subsequent detectable HCV RNA, and found nearly identical results. We also recalculated the reinfection rate among only those who identified IDU as their HCV risk factor. We used t tests and Fisher exact tests to examine the unadjusted associations between all baseline and on-treatment predictor variables and the outcome of HCV reinfection. Due to sample size considerations, we were unable to perform multivariable modeling of the reinfection outcome.

We conducted analyses in Excel 2016 (Microsoft Corp) and SAS 9.4 (SAS Institute). We used a two-tailed significance level of $P < 0.05$.

Human subjects

The study protocol was approved by the Boston Medical Center Institutional Review Board and deemed to meet minimal risk criteria with a waiver of informed consent granted in light of the retrospective nature of the study. Patients did not receive any payments for engaging in care with the HCV treatment team, nor were they retroactively contacted by the study team for the purposes of data collection.

Results

Baseline characteristics of treated and deferred patients

Five hundred ten adults were evaluated by the BHCHP HCV treatment team between January 2014 and March 2017, of whom 300 started treatment and 210 did not start treatment. Fig. 1 describes the cascade of HCV treatment.

Among treated patients (N = 300), the mean age was 49.8 years, 80.0% were male, and 52.3% were non-white (Table 1). All were homeless-experienced, and 29.0% were homeless at the time of treatment. A sizable proportion (30.7%) was unstably housed in residential substance use treatment programs of a transitional nature. There was a considerable burden of medical and mental health comorbidities, including hypertension (37.3%), HIV (20.3%), and major depressive disorder (52.7%). Over one-third (36.3%) had a diagnosis of AUD and

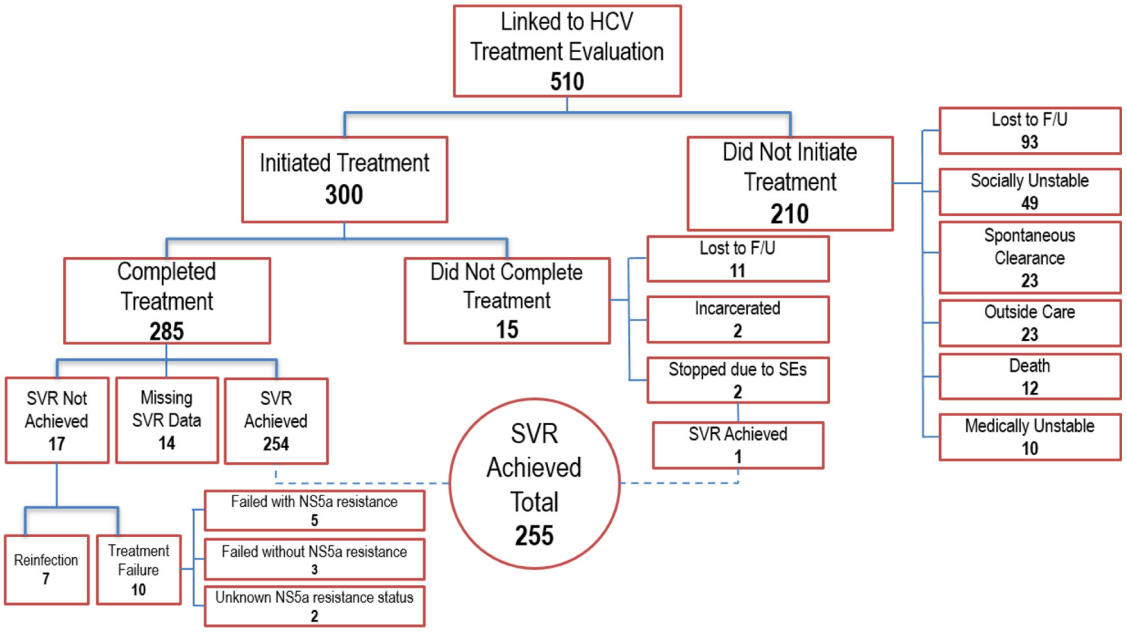

Fig. 1. Cascade of HCV care outcomes.

58.6% had a diagnosis of OUD. Most (73.9%) of those with OUD were receiving medications to treat their disorder.

In comparison to the treated cohort, untreated patients (N = 210) were about 4 years younger, more likely to be white non-Hispanic, and more likely to be homeless (Table 1). The proportion of patients with OUD was lower overall in the untreated group, but the proportion with untreated OUD was higher, as was the proportion with a history of recent opioid overdose ($p < 0.003$). Untreated individuals were more likely to have been recently incarcerated ($p = 0.002$) and less likely to be engaged in primary care at BHCHP ($p < 0.001$). The most common reasons for not initiating treatment were loss to follow up (44.3%) and social instability (23.3%).

HCV-related parameters

Among treated patients, genotype 1a was most common (65.7%) and a minority of patients (14.0%) had prior HCV treatment experience. Most treated patients (58.3%) had minimal fibrosis (F0-F1), while 20.0% had cirrhosis (F4). The FIB-4 index was the sole fibrosis assessment for 39.7% of the cohort. These individuals all had index scores predictive of minimal fibrosis. Four patients had a history of liver cancer.

On-treatment experience and process outcomes

The DAA regimens utilized and durations of treatment are described in Fig. 2. Almost all patients accessed HCV treatment through a public payer, either Medicaid (75.9%) or Medicare (22.4%).

Adherence support was largely provided through weekly calls by the HCV care coordinator (78.3%), but a subset of patients engaged in weekly nurse visits with pill box assistance (14.7%) or DOT (3.9%), and a few (3.1%) were treated while residing in an inpatient facility such as BHCHP's medical respite program. Adherence to treatment was generally good, with 78.0% reporting no missed doses of HCV medication.

On-treatment events were uncommon; 11.5% reported any drug or alcohol use, 12.2% experienced a change of address, 9.4% were hospitalized, 3.9% experienced an insurance interruption or change, and 1.8% were incarcerated at any point during treatment. Only 3.7% of patients were lost to follow-up during their medication course. The remaining individuals who did not complete treatment were incarcerated or stopped due to side effects.

Overall, 285 (95.0%) of the 300 individuals who initiated treatment completed the intended course of medication (Fig. 1). Of these, 271 (95.1%) completed follow-up testing ≥12 weeks post-treatment to assess for SVR. Delays in obtaining SVR testing were common and occurred on average 30.9 days after the 12-week post-treatment date.

SVR

Of the 300 treatment initiators, 255 (85.0%) achieved SVR (Fig. 1). This included 254 individuals who completed treatment and one individual who only completed six out of eight weeks of treatment but was later found to have achieved SVR. Excluding the 14 (4.9%) treatment completers who were lost to follow-up prior to 12-week testing yields a mITT SVR rate of 89.2%.

The unadjusted percentages achieving SVR by baseline and on-treatment characteristics are shown in Table 2. Eighty-seven percent of homeless individuals achieved SVR, and SVR rates did not vary significantly by baseline housing status. Greater medication adherence was associated with improved SVR, but the vast majority (86.1%) of those who missed between 1 and 7 doses, and over half (55.6%) of those reporting > 7 or an unknown number of missed doses, still achieved SVR.

In multivariable analyses of individuals whose SVR status was known (n = 286), HIV coinfection was associated with higher odds of achieving SVR (OR 10.4, 95% CI 1.33–82.00), while having bipolar disorder (OR 0.38, 95% CI 0.15 − 0.99), treated (OR 0.36, 95% CI 0.14 − 0.96) or untreated (OR 0.18, 95% CI 0.05 − 0.57) OUD, and on-treatment insurance change (OR 0.16, 95% CI 0.04 − 0.67) were associated with lower odds of SVR (Table 3). Importantly, relatively high percentages of individuals with bipolar disorder (78.9%) and treated (87.1%) or untreated (81.8%) OUD still achieved SVR.

In exploratory analyses, individuals with on-treatment insurance changes were more likely than those without insurance changes ($p = 0.029$) to miss medication doses, with over one-third (36.4%) missing at least a week or an unknown number of doses. There was no significant association between HIV infection ($p = 0.473$), OUD ($p = 0.375$) or bipolar disorder ($p = 0.369$) and missing medications.

Table 1
Baseline characteristics of treated and untreated individuals.

	Treated (N = 300)	Untreated (N = 210)	P value
Sociodemographic characteristics			
Age (years), mean (SD)	49.8 (10.5)	45.6 (11.1)	< 0.001
Gender, N (%)			0.251
Male	240 (80.0)	159 (75.7)	
Female	58 (19.3)	51 (24.3)	
Transfemale	2 (0.7)	0 (0)	
Ethnicity/race, N (%)			0.002
Hispanic	75 (25.0)	52 (24.8)	
Non-Hispanic black	82 (27.3)	30 (14.3)	
Non-Hispanic white	116 (38.7)	97 (46.2)	
Non-Hispanic other / unknown	27 (9.0)	31 (14.8)	
Veteran status, N (%)	17 (5.7)	10 (4.8)	0.693
Current housing status, N (%)			< 0.001
Housed	114 (38.0)	36 (17.1)	
Homeless[a]	87 (29.0)	102 (48.6)	
Residential / transitional treatment	92 (30.7)	66 (31.4)	
Other/unknown	7 (2.3)	6 (2.9)	
Incarcerated, past 6 months, N (%)	22 (7.3)	35 (16.7)	0.002
Primary care location, N (%)			< 0.001
BHCHP	234 (78.0)	139 (66.2)	
Outside BHCHP	51 (17.0)	30 (14.3)	
Unknown / unassigned / none	15 (5.0)	41 (19.5)	
Medical conditions			
Hypertension, N (%)	112 (37.3)	69 (32.9)	0.303
Diabetes, N (%)	44 (14.7)	27 (12.9)	0.605
Chronic kidney disease, N (%)	16 (5.3)	10 (4.8)	0.840
HIV infection, N (%)	61 (20.3)	34 (16.2)	0.250
Psychiatric conditions			
Major depressive disorder, N (%)	158 (52.7)	96 (45.7)	0.127
Generalized anxiety disorder, N (%)	107 (35.7)	81 (38.6)	0.515
Post-traumatic stress disorder, N (%)	91 (30.3)	60 (28.6)	0.694
Bipolar disorder, N (%)	39 (13.0)	36 (17.1)	0.206
Psychotic disorder, N (%)	23 (7.7)	10 (4.8)	0.206
Substance use			
Alcohol use disorder, N (%)	109 (36.3)	76 (36.2)	1.000
Opioid use disorder, N (%)			< 0.001
No	124 (41.3)	97 (46.2)	
Yes, treated	130 (43.3)	58 (27.6)	
Yes, untreated	46 (15.3)	55 (26.2)	
Opioid overdose, past 6 months, N (%)	3 (1.0)	12 (5.7)	0.003
Identifies injection drug use as risk factor for HCV, N (%)	244 (81.3)	170 (81.0)	0.909
Pre-treatment liver health			
Fibrosis stage			< 0.001
F0-F1	175 (58.3)	113 (53.8)	
F2-F3	65 (21.7)	12 (5.7)	
F4	60 (20.0)	33 (15.7)	
Unknown/Indeterminate	0	52 (24.8)	

[a] Individuals were considered homeless if the medical record indicated a usual nighttime residence of shelter, street, motel, or doubled-up.

Reinfection

Of 126 individuals with post-SVR follow-up data, 27 reinfections were identified during 206 person-years of follow-up (rate 13.1 per 100 person-years). Seven of these reinfections were identified at SVR assessment. They were differentiated from treatment failure on the basis of testing positive for a different HCV genotype. Median time to reinfection was 168 days (IQR = 81–207). All but one reinfection occurred among individuals who identified injection drug use as their pre-treatment risk factor for HCV acquisition. The reinfection rate among those with a history of injection drug use (n = 103) was 15.8 per 100 person-years over 165 person-years of follow up.

In univariate analyses, reinfected individuals were more likely to be Hispanic (p = 0.017), more likely to be homeless (p = 0.007), have a diagnosis of OUD (p = 0.012), have IDU as their baseline HCV acquisition risk factor (p = 0.026) and more likely to have had an address change during treatment (p = 0.004).

Discussion

We found that those who initiated HCV treatment in a community health centre-based program achieved high levels of treatment completion and SVR. However, many individuals did not initiate treatment despite initial linkage with the HCV team, chiefly because of loss to follow-up and superseding social issues. This underscores the need for improved cross-sector collaboration to enhance treatment uptake in this population with a high burden of SUDs and incarceration

Multivariable analysis of factors associated with SVR in the treated group showed that HIV coinfection was strongly associated with HCV cure. High achievement of SVR among individuals coinfected with HIV has been described elsewhere, including 96% cure rates among 335 individuals in a large phase 3 study (Naggie et al., 2015) and 90.9% cure rates among 996 veterans treated in routine practice (Bhattacharya et al., 2017). The favorable outcomes among HIV-infected individuals in our study could reflect the high level of support already built-in to other aspects of their care at BHCHP. The BHCHP HIV team has provided comprehensive HIV care supported by Ryan White funding since 1992, with an average HIV suppression rate of 80–90% during the years that these individuals received HCV treatment. Additionally, the HCV treatment team is comprised of clinicians who are also HIV care providers, creating opportunities for synergy within a care model that was already familiar to patients.

We found that homeless-experienced individuals with treated and untreated OUD who initiated HCV treatment had significantly lower levels of SVR compared to those without a diagnosis of OUD, although SVR achievement in these groups was still relatively high. A recent meta-analysis of HCV treatment outcomes among PWID demonstrated high SVR achievement among individuals with recent drug use whether or not they were on MOUD (Hajarizadeh et al., 2018). Our findings suggest that homeless-experienced people with OUD may need additional or specialized support during the HCV treatment process, such as a dedicated nursing model of HCV treatment described by Harney et al. (2019), or offering low barrier access to MOUD and enhancing counseling around relapse prevention and harm reduction. Modeling from Fraser et al. (2018) suggests that simultaneous scale up of HCV treatment, MOUD, and harm reduction services will be the most effective way to impact HCV incidence and achieve 2030 HCV elimination goals.

The rate of reinfection identified in this study is higher than that reported among PWID (Grebely et al., 2018; Martinello et al., 2017; Rossi et al., 2018). Local drug use dynamics may provide some explanation for this. BHCHP is situated in a hotspot of drug activity and opioid overdose (Bearnot, Pearson, & Rodriguez, 2018; Baggett et al., 2013). Although access to OUD treatment and syringe services is relatively good in the immediate vicinity, an opioid drug supply increasingly containing fentanyl, coupled with a recent rise in methamphetamine use, may be contributing to more frequent injecting behavior. This underscores the continued importance of syringe exchange services and other harm reduction programming, in addition to patient education, to mitigate reinfection risk.

It is not clear why individuals with bipolar disorder were significantly less likely to achieve SVR, although populations with serious mental illness (SMI) have historically experienced high rates of HCV and low rates of screening or engagement in HCV care (Hughes, Bassi, Gilbody, Bland, & Martin, 2016; Trager et al., 2016; Nikoo et al., 2018). Recently the psychiatry field has recognized the role it can play to support its patients with SMI through DAA HCV treatment (Chasser, Kim, & Freudenreich, 2017). A collaborative approach between HCV treaters and behavioral health providers may be an effective way to improve SVR achievement in this population.

Although on-treatment insurance lapses or changes were relatively uncommon, they were associated with a significantly lower likelihood of HCV cure, which appeared to be related at least in part to missed medication doses. This should be preventable. Unfortunately, the process for public insurance renewal is not well suited to individuals with

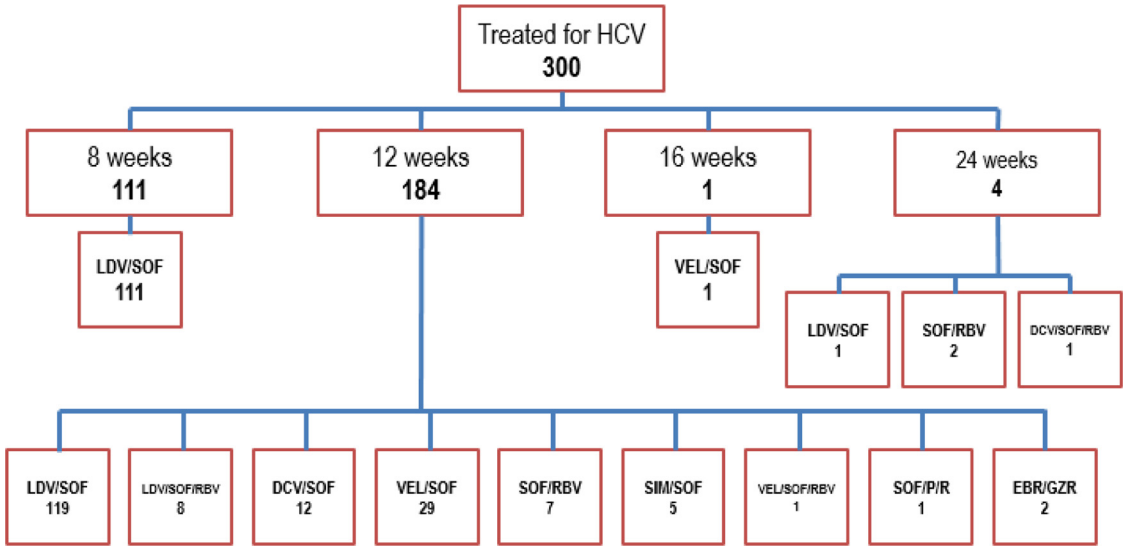

Fig. 2. Treatment regimes strafied by duration.

no reliable or fixed address. Improved transparency and accessibility to expiration and renewal logistics, and flexibility in pharmacy utilization to reduce delay would likely aid in prevention of insurance interruption.

Limitations

In this retrospective chart review study, data were collected from two medical record systems and are subject to the limitations inherent in clinically-captured data, including variability in clinician documentation practices and other factors that may lead to incomplete or inaccurate information for some participants. In particular, information on injection drug use behavior was limited in scope and did not capture the level of detail or dynamicity that would be desirable for a more nuanced assessment of this issue, so comparison to other literature on treatment completion and reinfection in IDU populations is limited. Chart abstraction for untreated patients was additionally limited by incomplete evaluations, so descriptive and clinical factors may be underestimated. Although multiple study staff abstracted the data, the use of a standardized abstraction procedure and data recording form helped to minimize inconsistencies in data capture. In addition, oversight from a clinical expert helped to ensure the medical accuracy of the abstracted data.

The observational nature of the study limits causal inferences around the predictors of SVR due to the possibility of residual confounding by unknown or unmeasured variables. In addition, the small number of failures to achieve SVR limited our power to detect other potentially important predictors of SVR that might emerge in a larger study.

Although the HCV treatment model presented here was situated within a homeless health care program, the majority of patients treated were not homeless at the time of treatment, and homeless patients referred for treatment evaluation were more likely to not initiate treatment. This signals a need to identify opportunities to better engage and support this subset of individuals. Since the time period under study here, the BHCHP HCV treatment team has expanded its programming to two shelter-based clinics and plans to engage street-homeless individuals on a mobile medical unit staffed by BHCHP addiction medicine clinicians and public-health advocates.

Finally, this study took place at a large, urban homeless health care program in a state with universal health insurance and a Medicaid program that has been historically generous in covering HCV treatments. As a result, our results may not be generalizable to other settings with different health policy environments.

Conclusions

Homeless-experienced individuals who initiated HCV treatment in a community health centre-based HCV treatment program were able to achieve high levels of HCV treatment completion and cure. Factors associated with a lower likelihood of cure were a history of bipolar disorder, treated or untreated opioid use disorder, and on-treatment insurance interruption or change. Engagement and retention in HCV treatment, and prevention of reinfection after SVR, will require collaborative effort across homeless health care, behavioral health, addiction and harm reduction sectors.

Role of funding source

None.

All study staff were supported internally by Boston Health Care for the Homeless Program for their time and efforts in this research.

Declarations of interest

Dr. Baggett receives royalty payments from UpToDate for authorship of a topic review on the health care of homeless people in the United States.

Conflict of interest statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Marguerite E. Beiser: Conceptualization, Methodology, Validation, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Kamala Smith:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing - review & editing, Visualization, Supervision, Project administration. **Molly Ingemi:** Conceptualization, Methodology, Software, Investigation, Writing - review & editing. **Emma Mulligan:** Investigation, Writing - review & editing. **Travis P. Baggett:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - review & editing, Visualization, Supervision.

Table 2
SVR rates among individuals with known SVR status (n = 286).

Characteristic	N	% who achieved SVR	P value*	Unadjusted OR (95% CI)
Sociodemographic				
Age			0.082	
< 50 years	121	85.1		Ref.
≥ 50 years	165	92.1		2.04 (0.96, 4.35)
Gender			0.715	
Male	226	88.5		Ref.
Female	53	91.4		1.38 (0.51, 3.76)
Transfemale	2	100		N/A[a]
Ethnicity/race			0.569	
Hispanic	73	90.4		Ref.
Non-Hispanic black	80	90.0		0.96 (0.33, 2.78)
Non-Hispanic white	108	86.1		0.66 (0.25, 1.70)
Non-Hispanic other / unknown	25	96.0		2.55 (0.30, 21.78)
Veteran status			1.000	
Yes	16	93.8		1.88 (0.24, 14.70)
No	270	88.9		Ref.
Current housing status			0.065	
Housed	112	94.6		Ref.
Homeless	84	87.0		0.38 (0.13, 1.06)
Residential / transitional treatment	84	84.5		0.31 (0.11, 0.85)
Other/unknown	6	83.3		0.28 (0.03, 2.82)
Incarcerated, past 6 months			0.708	
Yes	20	95.0		2.42 (0.31, 18.69)
No	266	88.7		Ref.
Primary care location			0.179	
BHCHP	227	90.8		Ref.
Outside BHCHP	45	82.2		0.47 (0.19, 1.14)
Unknown / unassigned / none	14	85.7		0.61 (0.13, 2.92)
Insurance status			0.268	
Medicaid (PCC Plan)	145	91.0		Ref.
Medicaid (MCO Plan)	72	81.9		0.45 (0.20, 1.02)
Medicare	64	92.2		1.16 (0.40, 3.41)
Private insurance	3	100.0		N/A[a]
Other	2	100.0		N/A[a]
Medical conditions				
Hypertension			0.331	
Yes	108	91.7		1.55 (0.69, 3.51)
No	178	87.6		Ref.
Diabetes			1.000	
Yes	43	90.7		1.22 (0.40, 3.68)
No	243	88.9		Ref.
Chronic kidney disease			1.000	
Yes	16	93.8		1.88 (0.24, 14.70)
No	270	88.9		Ref.
HIV infection			**0.009**	
Yes	61	**98.4**		9.23 (1.23, 69.12)
No	225	**86.7**		Ref.
Psychiatric conditions				
Major depressive disorder			0.568	
Yes	155	90.3		1.30 (0.62, 2.74)
No	131	87.8		Ref.
Generalized anxiety disorder			0.695	
Yes	105	90.5		1.25 (0.56, 2.76)
No	181	88.4		Ref.
Post-traumatic stress disorder			1.000	
Yes	89	89.9		1.12 (0.49, 2.54)
No	197	88.8		Ref.
Bipolar disorder			**0.045**	
Yes	38	**79.0**		0.38 (0.16, 0.93)
No	248	**90.7**		Ref.
Psychotic disorder			1.000	
Yes	23	91.3		1.30 (0.29, 5.84)
No	263	89.0		Ref.
Substance use conditions				
Alcohol use disorder			**0.048**	
Yes	107	**84.1**		0.45 (0.21, 0.95)
No	179	**92.2**		Ref.
Opioid use disorder			**0.042**	
No	118	**94.1**		Ref.
Yes, treated	124	**87.1**		0.43 (0.17, 1.08)
Yes, untreated	44	**81.8**		0.28 (0.10, 0.84)
HCV characteristics				
Injection drug use as identified risk factor for HCV acquisition			0.226	
Yes	231	87.9		0.42 (0.12, 1.43)

(*continued on next page*)

Table 2 (*continued*)

Characteristic	N	% who achieved SVR	P value*	Unadjusted OR (95% CI)
No	55	94.6		Ref.
Prior HCV treatment experience			0.415	
Yes	41	85.4		0.66 (0.25, 1.73)
No	245	89.8		Ref.
Genotype			0.186	
G1a	189	89.4		Ref.
G1b	40	95.0		2.25 (0.50, 10.03)
G2	22	86.4		0.75 (0.20, 2.76)
G3	26	77.0		0.39 (0.14, 1.10)
G4	9	100.0		N/A[a]
Fibrosis stage			0.470	
F0-F1	167	87.4		Ref.
F2-F3	62	93.6		2.09 (0.69, 6.34)
F4	57	89.5		1.22 (0.47, 3.20)
On treatment experience				
Pharmacy type			0.084	
BHCHP co-located pharmacy	231	90.9		Ref.
Mail-order specialty pharmacy	50	80.0		0.40 (0.18, 0.91)
Commercial Pharmacy	5	100.0		N/A[a]
Type of adherence support			0.374	
Weekly RN visits/pillboxes	42	90.5		1.09 (0.36, 3.32)
Directly observed therapy (DOT)	11	81.8		0.52 (0.11, 2.53)
Inpatient facility (BMH, SNF, etc)	9	77.8		0.40 (0.08, 2.04)
Monthly	224	89.7		Ref.
Reported substance use on treatment			0.146	
Yes	33	81.8		0.49 (0.19, 1.31)
No	253	90.1		Ref.
Reported incarceration on treatment			0.093	
Yes	5	60.0		0.17 (0.03, 1.08)
No	281	89.9		Ref.
Change of address on treatment			0.079	
Yes	35	80.0		0.42 (0.17, 1.07)
No	251	90.4		Ref.
Hospitalization on treatment			0.512	
Yes	27	85.2		0.67 (0.22, 2.08)
No	259	89.6		Ref.
Insurance change on treatment			**0.022**	
Yes	11	**63.6**		0.19 (0.05, 0.69)
No	275	**90.2**		Ref.
Reported missed doses on treatment			< **0.001**	
No missed doses	223	**93.7**		Ref.
1 ≤ missed doses < 7	36	**86.1**		0.42 (0.14, 1.23)
≥7 missed doses, or unknown amount	27	**55.6**		0.08 (0.03, 0.21)

* P value for Fisher exact test examining whether SVR rates differ significantly across levels of the variables displayed.

[a] Odds ratio calculation not applicable because all individuals achieved SVR.

Table 3
Adjusted analysis of factors associated with SVR, Odds Ratio Estimates (n = 286).

Adjusted Odds Ratio	95%Confidence Interval		
HIV infection	10.428	1.327	81.958
Bipolar disorder	0.38	0.146	0.989
Opioid use disorder, on treatment	0.36	0.135	0.964
Opioid use disorder, not on treatment	0.176	0.054	0.573
On treatment insurance change	0.16	0.038	0.671

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Acknowledgement

We thank Yuchiao Chang, PhD, for her input on the statistical analysis.

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