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Hepatitis C prevalence and incidence: A longitudinal study of young people who inject drugs and their injection network members

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Abstract

Aim: We examined predictors and correlates of prevalence and incidence of hepatitis C (HCV) in a sample of young people who inject drugs (PWID) in the Chicago, Illinois and the surrounding suburban and exurban areas that span 16 counties in northeast Illinois, southeast Wisconsin, and northwest Indiana.

Methods. Young (18-30) PWID were recruited for a longitudinal study of social networks and HCV (n=208). Participants received HCV antibody testing at baseline and at each 6-month follow-up for up to 36 months. We conducted interval-censored Cox regression analyses to test predictors and correlates of incident HCV infection, including sociodemographic variables, network measures, drugs injected, and injection practices. Residence in the past year was classified as urban, suburban, or crossover transient (moving between urban and suburban areas).

Results: During 162 person-years of follow-up, 17 out of 93 baseline HCV negative participants tested positive for HCV antibodies (IR = 10.5/100py, 95% CI 6.5-16.9). Young PWID who resided in Chicago at baseline (HR=4.18, 95% CI 1.40-12.48), moved between suburban and urban areas (HR=3.08, 95% CI 1.12-8.45), injected in abandoned buildings (HR=5.01, 95% CI1.73-14.51), and those with larger injection drug networks (HR=1.23, 95% CI 1.10-1.38) were at greater risk. Days of homelessness (HR=1.02, 95% CI 1.00-1.04), and injection behaviors during follow-up, including number of network members sharing syringes (HR=1.83, 95% CI 1.03-3.25), showed significant early effects that diminished over time.

Conclusions: In the Chicago metro area, HCV incidence among young PWID remains high. Suburban PWID are somewhat insulated from HCV exposure, while moving into the city may increase opportunities for exposure to HCV-infected injection partners. Injection in abandoned buildings, and larger and less redundant injection networks were also associated with increased risk of HCV seroconversion. Social-spatial mobility and network structure should be considered in HCV prevention and micro-elimination strategies targeting young PWID in metropolitan areas.

Keywords: people who inject drugs, hepatitis C, incidence, injection drug use, social networks, suburban

Background

Hepatitis C virus (HCV) infection is a leading cause of chronic liver disease and mortality, with an estimated 47 million chronic infections worldwide in 2024 and about 1.0 million new infections occurring per year.(1) Sharing contaminated injection drug use (IDU) syringes/needles and other equipment is the primary mode of HCV transmission in many countries, including the United States. The U.S. continues to be among countries with the highest HCV incidence rates.(1) HCV seroprevalence among people who inject drugs (PWID) in the U.S. has been estimated at 38% to 58% depending on geographic location,(2) and increases with duration of IDU exposure.(3) In the U.S., HCV is the most common bloodborne infection; an estimated 2.4 to 4 million people were chronically affected during 2017-2020,(4) and there were 101,525 newly reported chronic cases during 2023.(5) Fueled by the simultaneous increases in opioid and IDU(6-11) and exacerbated by the recent transition to synthetic opioids, with faster onset and shorter duration that may lead to more frequent injections, HCV incidence increased 129% between 2014 and 2021, with the highest rate among young PWID age 20–39 years in 2021.(12) Since 2021, the estimated number of annual acute HCV infections has levelled off at about 69,000.(5) These increases are particularly stark in rural and suburban populations, which is partly driven by inadequate access to and/or poor uptake of HCV testing and treatment, medication for opioid use disorder (MOUD), and harm reduction services (e.g., syringe services programs, HCV testing and counseling).(13-17)

In 2016, the World Health Organization (WHO) proposed that HCV elimination was feasible by 2030 and delineated strategies to achieve this goal, including 90% reduction in incidence, 80% of those with chronic HCV treated, and 65% reduction in liver-related mortality.(18) Currently, the U.S. lags behind 15 countries on track to meeting the 2030 HCV elimination goals.(19, 20) In 2022, the White House Office of Science Technology Policy defined plans for a U.S. HCV elimination program. Microelimination is a less daunting approach that entails pursuing elimination goals in discrete high-risk populations such as PWID that could build momentum by generating small victories towards success.[2] HCV microelimination strategies are urgently needed that focus on the estimated 1.3 million[5] PWID in the U.S., the group at most risk for acquiring and transmitting HCV infection.

Current estimates of HCV incidence, which are imperative for monitoring the epidemic and to adapt public health response and assess progress towards meeting the WHO and U.S. targets, are lacking. In the U.S.(21) The most recently available estimates of HCV incidence among PWID are 15-20 years old,(22-24) which does not reflect the patterns of the current opioid epidemic. Our recently completed longitudinal cohort study (Alter-Ego, 2018-2023) of

young PWID (ages 18-30) and their injection, sexual, and social support network members (all ages) examined the role of individual, social network, social norms, social geography, and stigma on HCV prevalence and incidence in Chicago, Illinois and the surrounding suburban and exurban areas that span 16 counties in northeast Illinois, southeast Wisconsin, and northwest Indiana.(25) In the present analysis, we examined correlates and predictors of prevalent and incident HCV infection among young PWID in the AlterEgo study, including injection network characteristics and geographic mobility.

Methods

Study design

We used longitudinal data collected from a network-based study of young (aged 18-30) PWID and their injection network members. between. Baseline data collection occurred from October 2018 to December 2021, and follow-up interviews of ego participants (i.e., initial participants who were asked to recruit their network members) were conducted every 6 months for a three-year period until October 2023.

To be eligible, ego participants (i.e., initial participants who were asked to recruit their network members) had to be (i) 18-30 years old, (ii) current injectors (i.e. injected ≥1 in past 30 days), (iii) willing to recruit their injection network alters who were ≥ 18 years old at baseline, (iv) willing to be tested for HIV and HCV, and (vii) residing in the Chicago Metropolitan Statistical Area in the past 12 months. The injection network members (i.e., alters) of the egos were eligible if they were (i) ≥ 18 years old and (ii) had injected drugs with the ego in the past 6 months. Current injector status was verified by experienced study staff inspecting injection stigmata and, if questionable, using a standardized procedure from earlier studies to evaluate participant knowledge of the injection process.(11) Age was verified with a driver's license or a state ID card. Project staff offered to assist those without identification in obtaining it. At their baseline visit, we asked each ego participant to recruit up to five alters (i.e., people they injected drugs with at least once in the prior six months) using recruitment coupons that provided information about the study and were linked to the recruiting ego via alphanumeric code. Coupons could only be redeemed by alters named by an ego participant during their survey. Data collection from alters was required to occur within 6 months of the ego's baseline visit.

All participants (egos and alters) completed surveys and HIV and HCV testing at baseline. Blood samples were collected for confirmatory testing. Egos were asked to return every 6 months for 36 months to complete follow-up surveys and HIV and HCV testing. The present analysis includes only ego participants.

Recruitment, Enrollment, and Compensation

The study was conducted at two field sites of a community outreach center located in Chicago, Illinois that has been providing prevention and drug use risk reduction services (e.g., syringe service programs; and HIV and HCV counseling, testing, and case management) and conducting research on people who use illicit substances for almost 40 years. The field sites are located in areas that have rates above the city's average for HIV/AIDS, sexually-transmitted infections, viral hepatitis, and arrests for drug-related offenses. The field sites and mobile van locations are also co-located with outdoor drug markets that attracts both urban and suburban PWID across a large metropolitan area.(25) We recruited most egos from the syringe services program (SSP) at these field sites. To enhance the representativeness of the suburban PWID population by targeting non-SSP suburban PWID, a sizeable proportion of egos were also recruited via other methods: direct recruitment in drug market areas and at community fairs using an outreach van; fliers posted at suburban community-based organizations serving PWID; and social media and other online ads.

To reduce bias and ensure a diverse sample, we used three approaches to recruit ego participants. First, we approached SSP participants daily to screen for eligibility and offer enrollment. Second, SSP-recruited participants were screened to ascertain if they obtained syringes at the SSP for other people who reside in the suburbs. We offered those who said yes a coupon to refer to the study an age-eligible peer who did not use the SSP or purchase/use drugs in Chicago. To encourage peer-recruited PWID to participate, we used a mobile outreach van staffed with an interviewer/phlebotomist, to conduct data collection off-site near the recruit's residence or other mutually agreed upon locations. Third, screening and enrollment of non-SSP PWID from drug market areas were done by community-indigenous field staff with extensive experience working in these areas and recruiting for similar studies. These recruitment methods resulted in a total sample of 169 ego participants.

Because the time needed to complete surveys that ask about social networks varies considerably depending on network size, we compensated participants hourly ($20 per hour; average time of about 2 hours). Most participants completed the survey within a 2.5-hour session that included a break (average $50). In addition to hourly compensation for interviews, egos were reimbursed $10 for each alter enrolled.

All participants (alters and egos) completed a process of informed consent. Appropriate counseling was provided to accompany HIV/HCV testing. All Community Outreach Intervention Project services (e.g., SSP; HCV and HIV testing, counseling, and case management; recovery support service and linkage to medical care) were made freely available to all PWID screened,

regardless of study enrollment. This study was conducted in accordance with the tenets of the Declaration of Helsinki. Study procedures were approved by an Institutional Review Board at the University of Illinois Chicago. Additional details about study procedures are published elsewhere.(26)

Measures

The baseline and follow-up survey instruments are available as supplemental material (Supplemental File 1).

Socio-demographics. Demographic variables included gender (male, female, or transgender), race/ethnicity (Hispanic/Latine, non-Hispanic white, non-Hispanic Black, and non-Hispanic other/mixed), and age at baseline. We also included baseline measures of current area of residence (urban vs. non-urban), crossover (urban-suburban) transience (i.e. reported residence in both urban and no-urban locations in the past year), and current homelessness. Time-varying measures included area of residence (urban vs. non-urban) at the time of assessment and crossover transience, number of days homeless, and being in jail during the past six months.

Injection drug use and risk behavior. Time invariant measures included years since first injected drugs. Time-varying measures were assessed for the past six months at each interval, including injection of speedball, crack, or methamphetamine, any receptive syringe sharing, sharing cookers, and backloading (filling syringe from another person's syringe).

Injection drug networks. Baseline network measures included (a) degree: size of the total IDU network; (b) effective size of core IDU network: a measure of redundancy, the more alters are connected to one another, the lower the effective size; (c) tie density: the percentage of actual connections out of the all possible ties; (d) global clustering coefficient: percentage of triplets of nodes where all three members are connected to each other; (e) constraint (weighted): the extent to which ego is strongly connected to alters who are in turn strongly connected to ego's other alters; and (f) between centrality: how often a node appears on the shortest path between two other nodes.

Network-level risk behaviors. From participant responses on the network survey, we computed measures of injection partner characteristics and risk behavior with injection partners, including the number of injection partners with whom the participant shared a) drugs, b) syringes, and c) ancillary injection equipment (cookers, cottons, water).

Common injection places. Participants reported on the places they injected in the past 6 months at baseline. For each place, they reported the location, the type of place, and how often they

injected at that location on a scale from (1) every day to (7) only once. We classified four place types (private home, car, abandoned building, and public place) and coded whether the participant injected more than once a week at each type of location.

Statistical Analysis

Analyses were conducted using Stata (v. 18). We examined predictors of loss to follow-up (defined as failure to return for at least one follow-up interview) among participants who had been enrolled for the complete follow-up period of 36 months using chi-square tests for categorical variables and logistic regression for continuous variables. We computed HCV incidence rate ratios for baseline and time-varying categorical predictors, and rate ratios and Mantel-Haenzel score test for trend for continuous predictors. To account for the uncertainty in time to infection, we conducted interval censored Cox regression analyses for baseline and time-varying covariates using the *stintcox* procedure.(27, 28) We tested the proportional hazards assumption using the tvc option to include an interaction with time.(27)

Results

Sample

A total of 208 young PWID were recruited and completed baseline interviews. Participants were 60% non-Hispanic [NH] white, 28% Hispanic (all races), and 29% female. The mean age was 27 (SD 2.7) and the mean duration of injection drug use was 6.9 years (SD 4.0). Sixty-eight percent (n=142) returned for at least one follow-up interview. Among the 176 participants who had been enrolled for 36 months, time of recruitment relative to the COVID-19 lockdown period was a significant predictor of loss to follow-up (per month, OR=1.11, 95% CI 1.03-1.20.) Also, participants who reported that they received most of their income from illegal activities were more likely to be lost to follow-up (43% vs. 18% for employment, 28% for other income, Chi2 = 8.68, p = 0.013), while those who had ever been in prison were less likely to be lost to follow-up (19% vs. 34%, Chi2=4.31, p=0.038.)

HCV prevalence. Characteristics of the sample and HCV antibody test results at baseline are shown in Table 1. Two participants were not tested due to COVID-19 disruption. Out of 206 baseline HCV tests, 28% (n=58) were antibody reactive and 72% (n=148) were not reactive. Valid confirmatory RNA test results were obtained for 47 participants; reasons for missing results (n=11) include inconclusive results (n=1), unsuccessful blood draw (n=8), and unable to draw blood due to COVID-19 disruption (n=2). Of the 47, 68% (n=32) were confirmed RNA positive (current/chronic infection) and 32% (n=15) were RNA negative (resolved infection).

Older age, homelessness, and Chicago residence were associated with HCV antibody positive status. Young Hispanic/Latine PWID were less likely to be HCV antibody positive (Chi2=10.33, p=0.001).

Table 1. Characteristics of young PWID & HCV antibody prevalence (N=208)

		HCV ab neg		HCV ab pos			
	N	*N*	*%*	*N*	*%*	*Chi2*	*p-value*
Total[a]	*208*	*148*	*71%*	*58*	*28%*		
Gender							
Male	146	106	73%	38	26%	3.04	0.218
Female	61	42	69%	19	31%		
Transgender	1	0	0%	1	100%		
Age							
18-24	39	33	85%	6	15%	8.81	0.012
25-29	145	103	71%	40	28%		
30-34	24	12	50%	12	50%		
Race-ethnicity							
Hispanic/Latine	56	51	91%	5	9%	29.38	< .0001
NH white	124	83	67%	40	32%		
NH Black	11	8	73%	3	27%		
Native American	8	0	0%	7	88%		
Other/mixed	9	6	67%	3	33%		
Homeless past 6 months							
No	69	57	83%	12	17%	5.94	0.015
Yes	139	91	65%	46	33%		
Current area of residence							
Chicago	124	81	65%	43	35%	6.55	0.010
Outside of Chicago	84	67	80%	15	18%		
Past year residences[b]							
Urban only	65	36	55%	29	45%	15.01	0.001
Suburban only	64	53	83%	10	16%		
Crossover transient	74	57	77%	16	22%		

[a] n=2 missing HCV test due to COVID-19 disruption

[b] n=5 missing, 3 HCV antibody positive

PWID: Persons who inject drugs; HCV: hepatitis C virus; ab: antibody

HCV incidence. Of the 148 participants with a negative HCV antibody test result at baseline, 99 (67%) completed at least one follow-up interview, and 93 had an HCV antibody test at follow-up. Six participants were interviewed remotely and not tested due to COVID-19 restrictions. During 162 person-years of follow-up, 17 out of 93 baseline HCV antibody negative participants tested positive for HCV antibodies (IR = 10.5/100py, 95% CI 6.5 – 16.9). Kaplan-Meier survival estimates are shown in Figure 1. Survival probabilities are calculated based on the number of individuals remaining uninfected divided by the number starting the interval.(29) The table below the graph shows the number of individuals entering the interval and the number infected. A table of the survivor function is available in the supplemental materials (Supplemental File 2, Table S1).

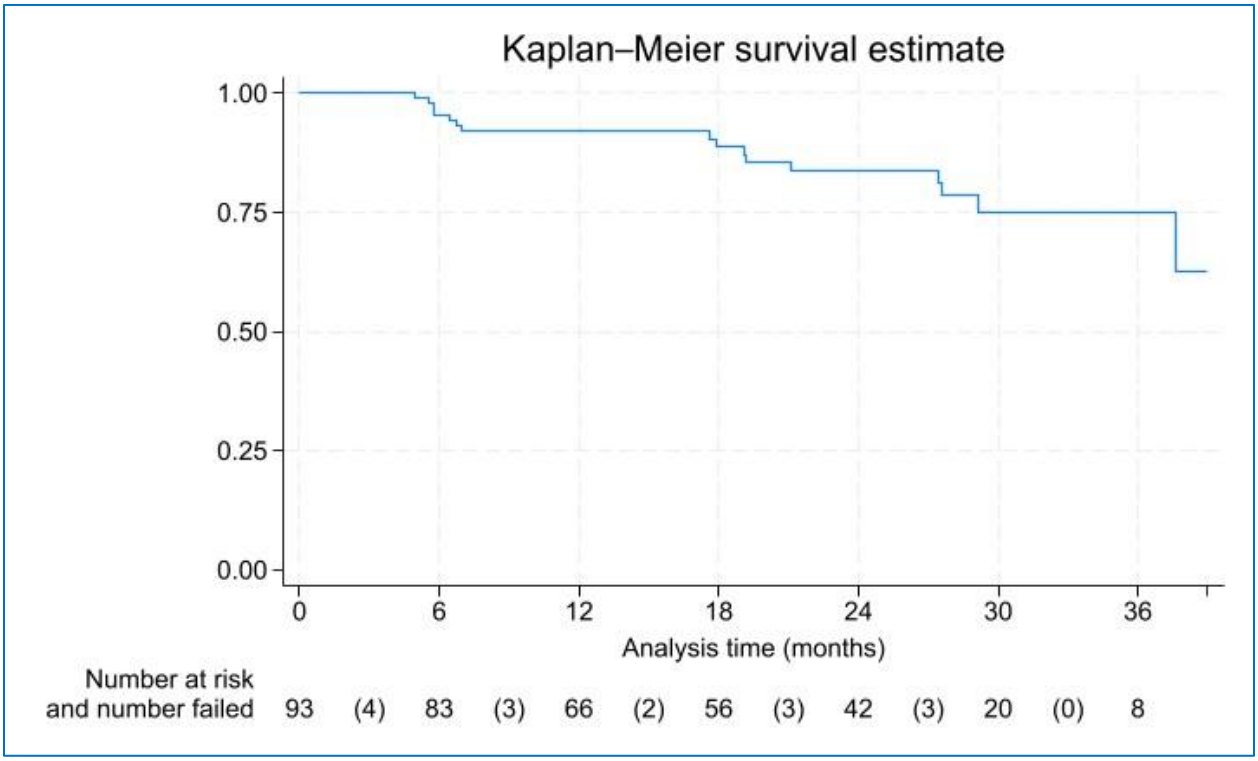

Figure 1. Kaplan-Meier survival curve for HCV incident infections among young people who inject drugs during 36-month follow-up

Baseline predictors. Baseline characteristics of the population with at least one follow-up (n=93) are shown in Table 2. Baseline predictors associated with incident HCV included urban-suburban transience in the past year (p=0.029), frequently injecting in abandoned buildings (p=0.003), injection network size at baseline (p<0.001), and core injection network effective size (p=0.001). Current urban residence was also associated with incident HCV (p=0.01), however a significant deviation from proportionality was detected (LRT Chi2[1]=11.47, p<0.001).

Nonparametric estimates for baseline residence are shown in Figure 2. The heightened risk due to baseline urban residence is apparent up to 18 months. As seen in Figure 1, the sample is significantly affected by attrition beyond this point.

Table 2. HCV incidence rates and hazard ratios from interval-censored Cox regression: Baseline characteristics of young PWID (N=93)

	IR	*p-value†*		*HR*	*Robust 95% Conf. Int.*	
Gender						
Male	0.12					
Female	0.07	0.422		0.58	0.16	2.08
Ethnicity						
Not Hispanic	0.11					
Hispanic	0.10	0.996		1.00	0.31	3.24
Current residence[a] *						
Lives outside Chicago	0.05					
Lives in Chicago	0.18	0.013		4.18	1.40	12.48
Homelessness						
Not currently homeless	0.08					
Currently homeless	0.17	0.172		2.25	0.57	8.87
Transience						
Urban or suburban only	0.07					
Crossover transient	0.20	0.034		3.08	1.12	8.45
Common injection places[b]						
Private home	0.08	0.149		0.46	0.17	1.21
Car	0.08	0.789		0.74	0.09	6.28
Abandoned building	0.27	0.009		5.01	1.73	14.51
Public place	0.07	0.195		0.48	0.15	1.54
	Score test for trend					
	Rate ratio	*Chi2*	*p-value*			
Age	1.07	0.57	0.45	1.09	0.87	1.37
Years since first IDU	0.96	0.54	0.46	0.95	0.80	1.13
Injection network size	1.29	11.22	0.001	1.23	1.10	1.38
<u>Core network measures:</u>						
Effective size	1.97	10.82	0.001	1.59	1.22	2.08
Tie density	0.04	4.33	0.037	0.06	0.00	1.03
Global clustering	1.68	0.82	0.366	1.92	0.29	12.46
Constraint (weighted)	0.20	3.46	0.063	0.20	0.03	1.41
Between centrality	1.96	0.78	0.377	1.79	0.61	5.26

† Mid-p-values for tests of incidence-rate difference (2-sided)

[a] n=92; * significant departure from proportional hazards, LR chi2(1) = 11.47, p=0.0007

[b] Injected in this type of place more than once a week; n=91

IR: incidence rate; HR: hazard ratio

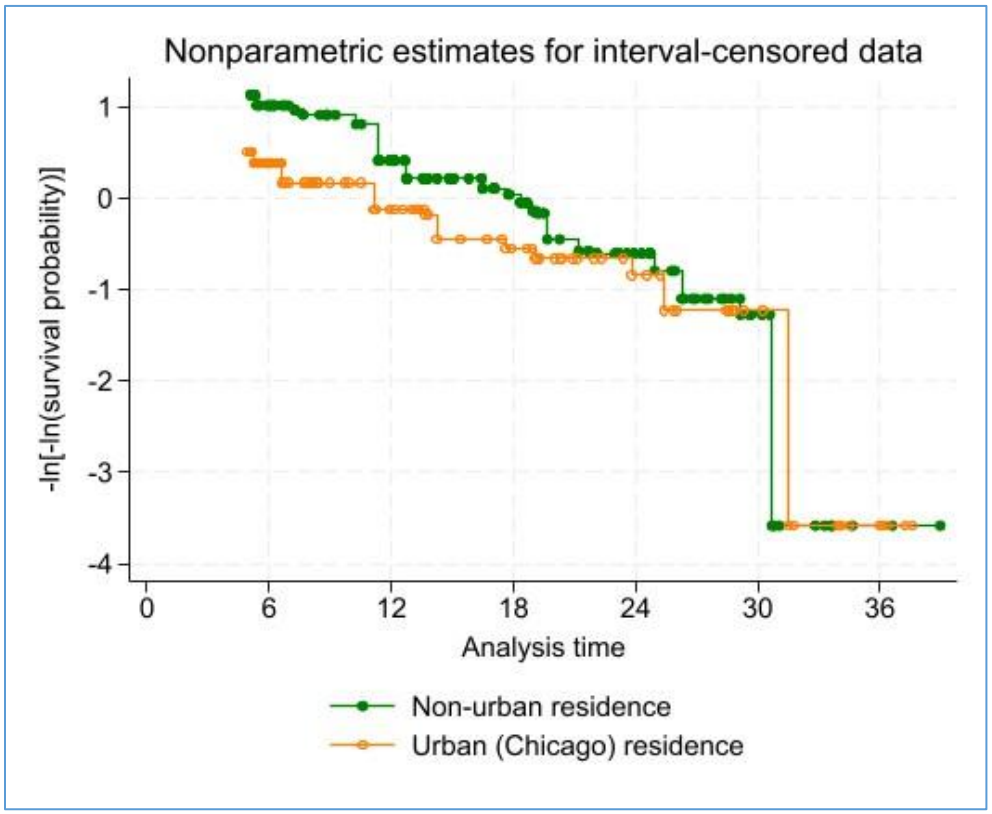

Figure 2. Survival by current residence at baseline, Chicago vs. outside of Chicago

In models stratified by baseline urban vs. non-urban residence, transience was not significant (HR=1.89, 95% CI 0.60-5.90), while injection network size (HR=1.19, 95% CI 1.04-1.37) and core network effective size (HR=1.48, 95% CI 1.10-1.99) remained significant. Frequently injecting in abandoned buildings also remained significant (HR=7.39, 95% CI 1.89-28.88). A map of injection places in Chicago (Figure 3) shows the clustering of abandoned buildings used for IDU on the West Side of the city.

Time-varying predictors. Tests of time-varying characteristics are shown in Table 3. We present the results with a time-varying component in those cases where the likelihood ratio test indicated a significant time-varying effect ($p<.05$). In all cases these effects represented an early effect that was diminished over time. Significant effects were detected for sharing cookers, days homeless, number of people sharing drugs, and number of people sharing syringes. The model for the time-varying effect of sharing cookers encountered a flat or discontinuous region during

estimation of standard errors resulting in uninterpretable confidence intervals. The magnitude of the estimated hazard ratios should be interpreted cautiously.

Table 3. HCV incidence rates and hazard ratios from interval-censored Cox regression: Time-varying characteristics of young PWID (N=93)

	IR	*p-value†*	*HR*	*Robust 95% Conf. Int.*	
Current residence					
Lives outside Chicago	0.064				
Lives in Chicago	0.193	0.027	2.94	0.87	10.00
Homelessness past 6 months					
Not homeless	0.057				
Homeless	0.162	0.044	2.06	0.64	6.59
Transience					
Urban or suburban only	0.109				
Crossover transient	0.091	0.823	1.22	0.41	3.64
Jail past 6 months					
No	0.083				
Yes	0.168	0.168	1.06	0.27	4.14
Injected speedball[a]					
No	0.074				
Yes	0.188	0.118	1.32	0.43	4.08
Injected crack cocaine[a]					
No	0.088				
Yes	0.136	0.497	1.38	0.44	4.27
Injected methamphetamine[a]					
No	0.088				
Yes	0.169	0.406	0.89	0.26	3.06
RSS					
No	0.088				
Yes	0.166	0.229	0.77	0.18	3.26
Shared cooker*[b]					
No	0.085				
Yes	0.133	0.370	10.07	10.07	10.08
TVC			0.88	0.88	0.88
LRT for TVC			Chi2(1)=4.30, p=0.038		
Backload					
No	0.075				
Yes	0.241	0.027	2.28	0.66	7.87

	Score test for trend		
	Rate ratio	*Chi2*	*p-value*

Days homeless*	1.01	7.78	0.005	1.02	1.00	1.04
TVC				0.998	0.997	1.000
LRT for TVC				Chi2(1)=5.33, p=0.021		
# shared drugs*	1.16	1.00	0.317	1.57	1.06	2.34
TVC				0.97	0.94	1.00
LRT for TVC				Chi2(1)=5.44, p=0.02		
# shared syringes*	1.53	1.26	0.262	1.83	1.03	3.25
TVC				0.94	0.87	1.02
LRT for TVC				Chi2(1)=4.08, p=0.043		
# shared ancillary equipment*	1.78	4.61	0.032	1.76	0.97	3.18
TVC				0.94	0.87	1.02
LRT for TVC				Chi2(1)=4.70, p=0.03		

† Mid-p-values for tests of incidence-rate difference

[a] n=89; * significant departure from proportional hazards (p<.05); [b] flat or discontinuous region encountered

IR: incidence rate; HR: hazard ratio; TVC: Time-varying coefficient; LRT: Likelihood ratio test for model with vs. without time-varying coefficient

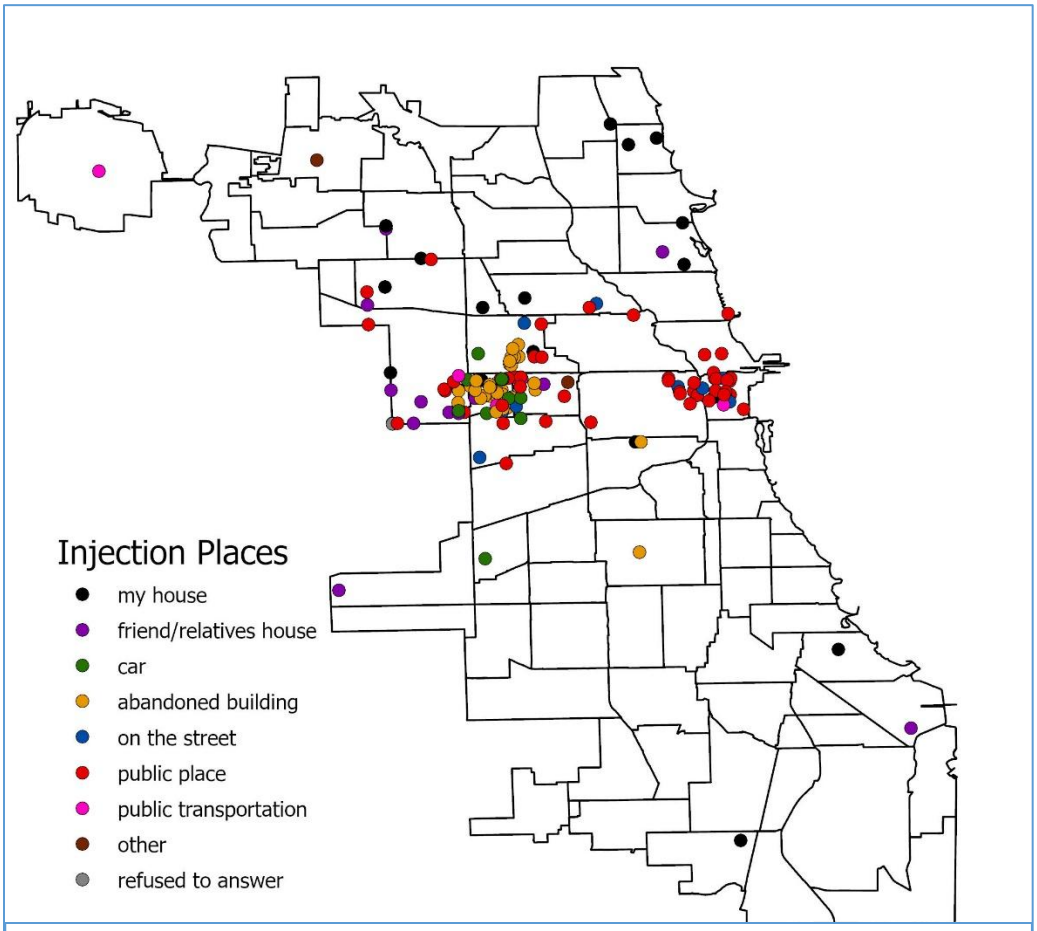

Figure 2. Injection locations in Chicago

Discussion

In this sample of young PWID, 28% of participants were HCV antibody positive at baseline, and the incidence of HCV infection was 10.5/100py (95% CI 6.5-16.9). Although slightly higher than the incidence rate reported in an earlier study of young PWID recruited in Chicago (2002-2005; 6.98/100py, 95% CI 3.63-13.42),(30) it falls within the 95% confidence interval of the earlier estimate. Consistent with prior research, older age, homelessness, and urban residence were associated with HCV prevalence. In this age-restricted sample, prevalence did not differ between non-Hispanic Black and white participants, contrasting with national trends, but all Native Americans with a test result (n=7) were positive, consistent with surveillance data showing high rates in this population.(5) Hispanic/Latine participants (71% Mexican/Mexican-American, 18% Puerto Rican) had significantly lower prevalence than non-Hispanic/Latine participants, driven by the high proportion of people of Mexican ethnicity, consistent with previous research.(31) Significant predictors of HCV incidence included geographic factors (living in Chicago vs. suburbs, or moving between urban and suburban areas), network characteristics and risk interactions, housing instability, and injection environment.

In Illinois, as with many states, HIV and HCV prevalence in urban areas are dramatically higher than their surrounding suburbs.(32, 33) Proximity and interaction with urban areas may be key to understanding the evolution of HCV risk among young suburban PWID. Alter-ego and our prior pilot study of young PWID identified a geographic bridging population that we named *cross-over transient*, as they reside and engage in IDU and sex activities in both the suburbs (low HCV prevalence) and disadvantaged Chicago neighborhoods (high HCV prevalence), potentially linking social networks that otherwise would not connect.(11, 25) While injecting in public places was not significantly associated with increased risk of HCV infection, injecting in abandoned buildings that are clustered on the West Side of Chicago, an area known as an open outdoor drug market and a hot-spot for risk activity,(25) emerged as a significant risk factor.

Network characteristics also influenced HCV incidence, with larger and less redundant networks (i.e. those with fewer connections between alters) increasing risk. Sharing injection equipment with more people also increased risk, as expected. Exposure to a broader set of injection partners increases opportunities for HCV transmission. Prior empirical and modelling studies have identified network size (degree) as a significant predictor of HCV acquisition.(34-36) Previous analyses of baseline data from this study found that crossover transient PWID tended to have larger and less redundant networks.(25) The increased risk tied to effective size may reflect this group’s exposure to higher-risk urban sub-networks.

Our study has several limitations. First, all in-person research was suspended for almost a year due to COVID-19 pandemic restrictions (March 2020-May 2021), resulting in limited to no biological specimen collection for HIV and hepatitis C collection and remote-only survey collection. This resulted in significant attrition since outreach activities for locating hard to reach unstably housed participants ceased for over a year. There were 55 participants who were not included in the analysis because they had no follow-up (n=49) or they did not have a valid follow-up HCV test result (n=6). Overall, retention was 70% among participants who were recruited at least 2 years before the study ended. Among HCV negative participants, 69% were re-interviewed but only 64% had a valid follow-up HCV test. Although we found no significant differences in baseline risk behaviors between participants included vs excluded, we cannot rule out selection bias. The high rate of attrition affected estimates of time-varying effects, and the small number of incident cases resulted in low precision of estimates.

Conclusion

In the Chicago metro area, HCV incidence among young PWID remains high. Suburban PWID are somewhat insulated from HCV exposure, while moving into the city may increase opportunities for exposure to HCV-infected injection partners. Injection in abandoned buildings, and larger and less redundant injection networks were also associated with increased risk of HCV seroconversion. Social-spatial mobility and network structure should be considered in HCV prevention and micro-elimination strategies targeting young PWID in metropolitan areas.

List of Abbreviations

HCV	hepatitis C virus
HR	hazard ratio
IDU	injection drug use
IR	incidence ratio
LRT	likelihood ratio test
MOUD	medications for opioid use
PWID	people who inject drugs
SD	standard deviation
SSP	syringe service program
WHO	World Health Organization

Supplemental Files

Supplemental File 1.pdf: Baseline and follow-up survey instruments

Supplemental File 2.docx: Supplemental table S1. Kaplan–Meier survivor function

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the tenets of the Declaration of Helsinki. Study procedures were approved by the Institutional Review Board at the University of Illinois Chicago. All participants completed a process of informed consent.

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and analyzed during the current study are available in the Open Science Framework repository, https://doi.org/10.17605/OSF.IO/VXAPQ.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

BB conceptualized the study and contributed to the writing of the manuscript. MM conducted the statistical analysis and prepared the initial draft of the manuscript. Both authors read and approved the final manuscript.

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Supplementary Files

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- SupplementalFile1.pdf
- SupplementalFile2.docx