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Hepatitis C incidence and prevalence among Puerto Rican people who use drugs in New York City

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ABSTRACT

Background: Hepatitis C virus (HCV) infection is associated with substantial morbidity and mortality among people who use drugs (PWUD). Health disparities related to race/ethnicity and immigration status also increase the risk of HCV infection and decrease the probability of linkage to care. Effective, curative treatment is now available for HCV infection and, alongside prevention, may eliminate HCV epidemics.

Methods: We examined HCV incidence, prevalence and associated risk factors among 5459 Puerto Rican (both PR-born and U.S.-born) and non-Puerto Rican (only U.S.-born) entrants to Mount Sinai Beth Israel drug treatment programs in New York City, from August 2005 to January 2018, to assess the need for HCV screening, prevention and treatment in this population.

Results: HCV incidence and prevalence among Puerto Rican PWUD was significantly greater than the non-Puerto Ricans PWUD. Among people who inject drugs (PWID), there was no difference in injection risk behaviours by ethnicity/birth place.

Conclusions: Findings suggest HCV treatment is a necessary component of a strategy to eliminate HCV epidemics among PWUD. Findings also underline the interconnectedness of epidemics across regions, such that to eliminate the HCV epidemic in one location may depend on eliminating the HCV epidemics in other locations.

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HCV; Puerto Ricans; injection drug use

Introduction

Hepatitis C virus (HCV) infection is one of the most prominent threats to the health of people who use drugs (PWUD), especially people who inject drugs (PWID). In the USA and Canada, HCV is associated with an average of 810,000 Disability-Adjusted Life Years (DALYs; a measure that combines years of life lost as a result of premature death and years lived with severe disability) (Degenhardt et al., 2016). World Health Organization (WHO), national, regional and local health policymakers have targeted the elimination of HCV as a public health threat. However, HIV prevention and treatment strategies, which have already achieved great success in reducing HIV incidence, morbidity and mortality among PWID, have had little impact on HCV incidence (Coutinho, 1998). To eliminate HCV as a public health threat it is essential to identify and address the factors that are associated with the divergence of HIV and HCV incidence rates.

Both differences in transmissibility and in prevalence of HCV, in comparison to HIV, have been proposed to explain the continued high HCV incidence in different populations and settings. A key

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factor is the greater per-act transmissibility rate of HCV through the parenteral route, compared to HIV (Coutinho, 1998). In healthcare settings, for example, risk of HCV transmission following needlestick injury from an HCV-infected source is estimated at 2% (US Public Health Service, 2001), 10 times higher than the 0.2% risk of HIV transmission in similar circumstances (Patel et al., 2014). Moreover, HCV transmission risk is not limited to exposure through needles. Efficient transmission also occurs through sharing injection water and other injection equipment, such as cotton and cookers, and may be as high as 6% (Boelen et al., 2014). Not only does HCV have a more efficient parenteral transmission compared to HIV, it also has a higher probability of transmission due to its greater prevalence among PWID. The high prevalence of HCV confers a greater per-act risk of HCV infection independently of the efficiency of HCV transmission, as a result of greater likelihood of contamination of injection equipment (Coutinho, 1998).

Disparities associated with race/ethnicity and immigration status further impact HCV prevalence and associated risk behaviours. Lower rates of injection risk behaviours have been reported among Blacks, compared to Whites (Des Jarlais et al., 2009; Williams et al., 2013), but higher rates of injection risk behaviours have been reported among migrants compared to U.S.-born PWID (Gelpí-Acosta et al., 2016). Differences in HCV prevalence have also been reported, as described below. HCV screening data among U.S. veterans has shown a higher prevalence of HCV among Blacks (Backus et al., 2014). A higher prevalence of HCV was reported among non-Hispanic Blacks compared to non-Hispanic Whites (Hall et al., 2018). A higher prevalence of HCV has also been reported among Puerto Ricans, compared to the overall U.S. population (Pérez et al., 2007). Further, within the Puerto Rican population, differences by migration status have been reported.

Among migrant Puerto Rican PWID in New York City a higher HCV prevalence was reported compared to U.S.-born Puerto Ricans (Gelpí-Acosta et al., 2016). The higher prevalence among migrants might reflect the greater rate of HCV prevalence in the general population of Puerto Rico (Pérez et al., 2007). This context of higher HCV prevalence would be expected to increase the risk of HCV infection associated with drug use risk behaviours. The study also reported greater rates of injection risk behaviours among migrant Puerto Ricans, in comparison with U.S.-born Puerto Ricans, suggesting increased risk of HCV infection among migrants, even if their HCV prevalence were similar to U.S.-born Puerto Ricans. The authors cite disparities between Puerto Rico and New York City in access to drug treatment, syringe exchange programs, and HIV prevention services as factors accounting for the greater HIV incidence and prevalence among migrants. The same disparities would have also contributed to greater HCV incidence and prevalence. In addition, increased HCV infection rates are associated with injection partner network characteristics and non-needle sharing injection risk behaviours, such as sharing cookers and rinse water.

The aim of the present study was to assess the differences in incidence and prevalence of HCV and identify associated factors among Puerto Ricans born in Puerto Rico (PR), Puerto Ricans born in the U.S.A, and non-Puerto Ricans born in the U.S.A, in a sample of PWUD entering drug treatment in New York City. The study was designed to address some of the existing gaps in the literature by assessing HCV incidence and prevalence among people with non-injecting drug use (NIDU), and by examining difference in access to healthcare.

Methods

Participants

This study, including the procedure for obtaining informed consent, was approved by the Mount Sinai Beth Israel Institutional Review Board. Data were collected as part of a serial cross-sectional study of risk factors for HIV among entrants to the Mount Sinai Beth Israel detoxification and methadone maintenance treatment programs (Des Jarlais et al., 1989). For recruitment from detoxification program, trained interviewers constructed a list of potential participants by visiting the admissions wards of the program each weekday and examining the intake records to identify patients

admitted in the previous 3 days. For recruitment from the methadone program, a list was constructed of newly admitted patients (within the previous 30 days). Eligibility criteria included a minimum of 18 years of age, using illicit drugs in the previous 6 months, and no participation in the study in the previous year. All eligible patients were approached, 95% of whom agreed to participate in the study. Multiple participation in different years was allowed. The study was fully described to each potential participant and a signed informed consent was obtained. For the current study, all entrants to the drug treatment programs between August 2005, when HCV testing was implemented, and January 2018 were included.

Measures

A questionnaire was administered to collect demographic data, as well as information regarding history of drug use, current drug use, injection risk variables, sexual behaviours, history of HCV and HIV testing, utilising HIV prevention and treatment services, general health status, and history of HIV antiretroviral treatment. For the present study, we only analysed demographic data, history of drug use, current drug use, injection risk variables, history of HCV testing, and utilisation of HIV prevention and treatment services. Current drug use, such as frequency of using heroin, and injection risk variables, such as sharing needles, measured behaviours occurring in the previous 6 months. Injection risk variable included injecting with needles others had used (receptive sharing), lending to others needles the participant had already used (distributive sharing), and sharing rinse water, cookers, water containers and cotton that was used in drug preparation. All participants who reported being born outside the 50 U.S. states and the District of Columbia were classified as non-U.S.-born. After the questionnaire was completed, pretest HIV counselling was conducted and venous blood samples were collected. HCV antibody testing was conducted, using the Abbott HCV enzyme immunoassay (EIA) 2.0 test. Confirmatory HCV RNA testing was not conducted.

Statistical analyses

We used Stata 15 to analyse the data (StataCorp, 2017). The chi-squared test was used to assess the differences in bivariate proportions and distribution of categorical variables. ANOVA was used to test the overall differences in continuous variables, followed by the *t*-test to compare specific groups, with *p*-values adjusted by the Bonferroni method for multiple comparisons.

We used logistic regression analysis to model the association of ethnicity/birthplace with HCV serostatus. Analyses were stratified on the basis of injection status, because, by definition, risk factors related to injection use of drugs comprise a different constellation of factors (e.g. sharing syringes, cooker or rinse water) than non-injection use of drugs (e.g. sharing non-injection drug paraphernalia). Logistic models were constructed separately for the PWID and for NIDU. Demographic variables, such as age and gender, which have been reported by other studies (e.g. Des Jarlais et al., 2018; Gelpí-Acosta et al., 2016) to be associated with HCV serostatus were included in the logistic models. Injection risk variables were included and consisted of the numbers of years since first injection, past 6 months frequency of injecting, injecting with a needle someone else had used, lending used needles to other injectors, and sharing injection equipment (i.e. injection water, water containers, cookers and cotton).

Because certain drugs are associated with risk behaviours, drug use variables were included as covariates in the models. The association of each potential predictor or important factor with positive HCV serostatus was first tested in univariate logistic models. All variables that were at least moderately associated with positive HCV serostatus in univariate models (i.e. $p < 0.15$) were then entered into the multivariable model and tested using backward elimination, following Agresti's approach, until we arrived at the final models (Agresti, 2003).

We also constructed cohort data on the basis of the limited number of repeat participants in the study. We used the cohort data to analyse HCV incidence and examine its association of ethnicity/

birthplace. For the cohort analyses, we only included participants with repeated participation over the period of study who were HCV negative at first participation. We assumed that any seroconversion had occurred halfway between last seronegative result and first seropositive result. Time-at-risk was measured as total time between seronegative results, plus, half the time from last seronegative result to first seropositive result. If no seroconversion occurred, time-at-risk was equal to the total time from first participation to last participation. NIDU participants who transitioned to injection drug use were included in a distinct category, so as to differentiate their risk profiles and HCV incidence from PWID and NIDU and compare them to the latter two groups.

Results

Between August 2005 and January 2018, we recruited 533 PR-born Puerto Rican, 1248 U.S.-born Puerto Rican and 3678 non-Puerto Rican, U.S.-born study participants among PWUD entering the Mount Sinai Beth Israel drug treatment programs. The proportion of PWID was greatest among PR-born Puerto Rican participants (59%), followed by U.S.-born Puerto Rican participants (48%), compared to non-Puerto Ricans born in the U.S.A (29%). Among PWID, 90% of PR-born Puerto Rican participants and 81% of U.S.-born Puerto Rican participants, compared to 38% of non-Puerto Rican participants, had injected with a Hispanic PWID in the previous 6 months (χ^2 (2) = 232.0; $p < 0.001$). Greater proportions of PR-born and U.S.-born Puerto Rican PWID participants (21% and 25%, respectively) reported injecting with someone they knew to be HIV positive, compared to 15% of non-Puerto Rican participants (χ^2 (2) = 8.6; $p < 0.05$), in the previous 6 months. Among NIDU, greater proportions of PR-born Puerto Rican participants (58%) and U.S.-born Puerto Rican participants (50%), compared to 43% of non-Puerto Rican participants, reported knowing someone who was HCV positive (χ^2 (2) = 21.3; $p < 0.001$). Tables 1 and 2 present demographic, drug use characteristics and HCV prevalence by ethnicity/birthplace among PWID and NIDU.

Non-Puerto Rican PWID had a significantly greater proportion of females (19%) than U.S.-born and PR-born Puerto Rican PWID (13%, and 10%, respectively). They were also significantly younger than both U.S.-born Puerto Rican PWID and PR-born PWID and had fewer years of injection than PR-born PWID. Puerto Rican PWID had significantly greater proportions who injected speedball and cocaine and injected on a daily basis, compared to non-Puerto Ricans.

Past 6 months injection risk behaviours, including injecting with used needles, lending used needles to others, and sharing injection water and equipment did not vary across groups. Significantly greater proportions of PR-born and U.S.-born Puerto Rican PWID used syringe exchange programs than non-Puerto Rican PWID (49% of PR-born and 43% of U.S.-born Puerto Rican PWID vs. 37% of non-Puerto Rican PWID, $p < 0.001$). A significantly smaller proportion of those who received all their sterile syringes from syringe exchange programs reported injecting with used needles and syringes from others, compared to those who did not receive all their syringes from syringe exchange programs (11% vs. 23%, $p < 0.001$). Similarly, a significantly smaller proportion of those who received all their sterile syringes from syringe exchange programs reported lending syringes and needles they had already used to others, compared to those who did not receive all their syringes from syringe exchange programs (11% vs. 17%, $p < 0.005$).

Non-Puerto Rican PWID had been in drug treatment a greater average number of times ($\bar{X}(SD) = 20(17)$) than both PR-born ($\bar{X}(SD) = 14(13)$, $p < 0.001$) and U.S.-born Puerto Rican PWID ($\bar{X}(SD) = 18(15)$, $p = 0.04$). A greater proportion of non-Puerto Rican PWID had used emergency room services or had visited a physician's office in the previous year. In contrast, a smaller proportion of non-Puerto Rican and U.S.-born Puerto Rican PWID had stayed at a shelter or received welfare assistance and food-stamp in the previous year. HCV prevalence was significantly greater among PR-born PWID (86%), compared to U.S.-born Puerto Rican PWID (70%, $p < 0.001$), and non-Puerto Rican PWID (62%, $p < 0.001$). U.S.-born Puerto Rican PWID also had a significantly greater prevalence of HCV than non-Puerto Rican PWID ($p < 0.001$). HCV prevalence decreased

Table 1. Demographic, drug use characteristics and HCV prevalence by PR vs. U.S.-born status among PWID entrants to Mount Sinai Beth Israel drug treatment programs in New York City (2005–2018).

	PR-born Puerto Ricans *N* (%)	U.S.-born Puerto Ricans *N* (%)	Non-Puerto Ricans *N* (%)	Test statistic (degrees of freedom); *p*
Total	312 (100)	603 (100)	1057 (100)	
Avg. age (SD)*	42 (9)[b]	41 (8)[a]	40 (11)[ab]	$t = -2.5$; 0.04[a] $t = -3.4$; 0.001[b]
Avg. years injecting (SD)*	18 (12)[ab]	16 (11)[b]	15 (13)[a]	$t = -4.3$; <0.001[a] $t = -3.0$; 0.01[b]
Gender*				$\chi^2 = 21$ (2); <0.001
Male	282 (90)	522 (87)	853 (81)	
Female	30 (10)	78 (13)	201 (19)	
Non-injection drug use				
Speedball	28 (9)	71 (12)	143 (14)	$\chi^2 = 5$ (2); 0.09
Heroin*	126 (40)	285 (47)	567 (54)	$\chi^2 = 19$ (2); <0.001
Cocaine	71 (23)	128 (21)	275 (26)	$\chi^2 = 5$ (2); 0.07
Crack*	88 (28)	207 (34)	505 (48)	$\chi^2 = 52$ (2); <0.001
Injection drug use				
Speedball*	169 (54)	250 (41)	410 (39)	$\chi^2 = 24$ (2); <0.001
Heroin	290 (93)	566 (94)	986 (93)	$\chi^2 = 0.2$ (2); 0.91
Cocaine*	153 (49)	241 (40)	454 (43)	$\chi^2 = 7$ (2); 0.03
Daily injection*	256 (82)	452 (75)	729 (69)	$\chi^2 = 23$ (2); <0.001
Receptive sharing	66 (21)	123 (20)	222 (21)	$\chi^2 = 0.1$ (2); 0.95
Distributive sharing	48 (15)	87 (14)	179 (17)	$\chi^2 = 2$ (2); 0.39
Sharing cookers	90 (29)	166 (27)	256 (24)	$\chi^2 = 4$ (2); 0.15
Sharing rinse water	63 (20)	118 (20)	200 (19)	$\chi^2 = 0.3$ (2); 0.87
Sharing cotton	67 (22)	143 (24)	218 (21)	$\chi^2 = 2$ (2); 0.34
Medical & other services				
Emergency room visit	102 (33)	229 (38)	453 (43)	$\chi^2 = 12$ (2); 0.003
Doctor's office visit	99 (32)	189 (31)	440 (42)	$\chi^2 = 22$ (2); <0.001
Any stay at shelter	108 (35)	134 (22)	259 (25)	$\chi^2 = 18$ (2); <0.001
Welfare assistance	173 (55)	301 (50)	451 (43)	$\chi^2 = 19$ (2); <0.001
HCV+*	269 (86)	423 (70)	651 (62)	$\chi^2 = 69$ (2); <0.001

*Significant overall difference across groups.
[a,b]Groups with same superscript letter were significantly different from each other in post-hoc, pairwise comparisons of the corresponding continuous variable. *P*-values were adjusted by Bonferroni correction.

Table 2. Demographic, drug use characteristics and HCV prevalence by PR vs. U.S.-born status among NIDU entrants to Mount Sinai Beth Israel drug treatment programs in New York City (2005–2018).

	PR-born Puerto Ricans *N* (%)	U.S.-born Puerto Ricans *N* (%)	Non-Puerto Ricans *N* (%)	Test statistic (degrees of freedom); *p*
Total	221(100)	645 (100)	2621(100)	
Avg. age (SD)*	46 (9)[b]	42 (8)[ab]	45 (8)[a]	$t = -6.3$; <0.001[a] $t = -8.0$; <0.001[b]
Gender*				$\chi^2 = 2$ (2); 0.32
Male	184 (83)	507 (79)	2083 (79)	
Female	31 (14)	134 (21)	534 (20)	
Non-injection drug use				
Speedball*	55 (16)	82 (13)	214 (8)	$\chi^2 = 19$ (2); <0.001
Heroin*	153 (69)	427 (66)	1124 (43)	$\chi^2 = 151$ (2); <0.001
Cocaine	100 (45)	294 (46)	1091 (42)	$\chi^2 = 4$ (2); 0.14
Crack*	101 (46)	316 (49)	1909 (73)	$\chi^2 = 180$ (2); <0.001
Medical & other services				
Emergency room visit	79 (36)	230 (36)	1079 (41)	$\chi^2 = 8$ (2); 0.02
Doctor's office visit	91 (41)	224 (35)	1083 (41)	$\chi^2 = 10$ (2); 0.01
Any stay at shelter	64 (29)	121 (19)	773 (29)	$\chi^2 = 30$ (2); <0.001
Welfare assistance	133 (60)	349 (54)	1437 (55)	$\chi^2 = 3$ (2); 0.27
HCV+*	44 (20)	77 (12)	303 (12)	$\chi^2 = 13$ (2); 0.001

*Significant overall difference across groups.
[a,b]Groups with same superscript letter were significantly different from each other in post-hoc, pairwise comparisons of the corresponding continuous variable. *P*-values were adjusted by Bonferroni correction.

significantly ($p < 0.05$) over the period of study only among non-Puerto Rican PWID (from 72%, in the first 3 years of the study period, to 51%, in the last 3 years of the study period).

Among NIDU, U.S.-born Puerto Rican participants were significantly younger than both PR-born and non-Puerto Rican participants. PR-born and U.S.-born Puerto Rican NIDUs, in comparison to non-Puerto Rican NIDUs, had greater proportions who used speedball and heroin, but smaller proportions who smoked crack cocaine. Non-Puerto Rican NIDU had been in drug treatment a greater average number of times ($\bar{X}(SD) = 15(14)$) than both PR-born ($\bar{X}(SD) = 11(11)$, $p < 0.001$) and U.S.-born Puerto Rican NIDU ($\bar{X}(SD) = 13(13)$, $p < 0.005$). A greater proportion of non-Puerto Rican NIDU had used emergency room services, compared to U.S.-born and PR-born Puerto Rican NIDU, and visited a physician's office, compared to U.S.-born Puerto Rican NIDU, in the past year. HCV prevalence was significantly greater among PR-born NIDUs (20%) than U.S.-born Puerto Rican and non-Puerto Rican NIDUs (12%, $p = 0.001$).

In multivariable logistic regression model of HCV prevalence among PWID, Puerto Rican ethnicity was associated with greater risk of positive HCV serostatus (see Table 3). PR-born Puerto Rican PWID had almost three times the odds of positive HCV serostatus of the non-Puerto Rican PWID. HCV positive serostatus was positively associated with age, years since first injection, daily injection, injecting speedball, using syringe exchange, and sharing cookers, and negatively associated with non-injecting use of speedball and heroin.

In multivariable logistic regression model of positive HCV serostatus among NIDU, also, PR-born Puerto Rican participants had greater odds of positive HCV serostatus than non-Puerto Rican NIDU (see Table 4). HCV positive serostatus was positively associated with age, years since first drug use, and using speedball, and negatively associated with using cocaine.

The cohort data consisted of 20 PR-born Puerto Rican, 55 U.S.-born Puerto Rican and 254 non-Puerto Rican, PWID and NIDU with repeated participation in the study. There were no significant differences in age or injection risk behaviours across ethnicity/birthplace among PWID. There were 12 seroconversions among the 52 PWID, 3 seroconversions among the 253 NIDU and 4 seroconversions among the 18 NIDU who transitioned to injection drug use. There were no significant differences in proportions of seroconversion or in incidence rate across ethnicity/birthplace groups among PWID (100 per 1000 PY at-risk, among PR-born Puerto Rican PWID vs. 64, and 39 per 1000 PY at-

Table 3. Odds ratios for HCV infection among non-Puerto Rican, PR-born Puerto Rican, and U.S.-born Puerto Rican PWID entering Mount Sinai Beth Israel drug treatment program in NYC (2005–2018).

	HCV seropositivity		
	OR (95% CI)	AOR (95% CI)	*p*
PR-born Puerto Rican*	3.90 (2.76–5.51)	2.71 (1.85–3.97)	<0.001
U.S.-born Puerto Rican*	1.47 (1.18–1.82)	1.27 (0.99–1.63)	0.06
Non-Puerto Rican (ref)	1.0	1.0	
Female*	0.93 (0.72–1.19)	1.41 (1.04–1.90)	<0.05
Male (ref)	1.0	1.0	
Age*	1.08 (1.06–1.09)	1.04 (1.02–1.05)	<0.001
Years injecting*	1.10 (1.09–1.11)	1.08 (1.06–1.10)	<0.001
Prior drug treatment	1.02 (1.01–1.02)	1.00 (0.99–1.01)	0.87
Daily injection*	1.40 (1.15–1.72)	1.49 (1.15–1.93)	<0.01
Syringe exchange*	2.00 (1.53–2.60)	1.36 (1.00–1.85)	<0.05
Sharing cookers*	1.46 (1.17–1.81)	1.46 (1.13–1.90)	<0.01
Sharing rinse water	1.44 (1.13–1.84)	1.25 (0.81–1.92)	0.32
Sharing cotton	1.38 (1.10–1.74)	0.98 (0.54–1.75)	0.93
Sharing water container	1.42 (1.11–1.82)	1.04 (0.67–1.59)	0.87
Speedball (injected)*	1.67 (1.37–2.04)	1.44 (1.08–1.92)	<0.05
Cocaine (injected)	1.51 (1.24–1.83)	1.32 (0.99–1.75)	0.06
Speedball (sniffed)*	0.54 (0.41–0.71)	0.43 (0.30–0.60)	<0.001
Heroin (sniffed)*	0.50 (0.41–0.60)	0.57 (0.45–0.72)	<0.001
Cocaine (snorted)	0.60 (0.49–0.74)	0.78 (0.58–1.05)	0.10
Crack Cocaine (smoked)	0.80 (0.67–0.96)	0.92 (0.72–1.17)	0.48

*Included in the final model after backward elimination.

Table 4. Odds ratios for HCV infection among non-Puerto Rican, PR-born Puerto Rican, and U.S.-born Puerto Rican NIDU entering Mount Sinai Beth Israel drug treatment program in NYC (2005–2018).

	HCV seropositivity		
	OR (95% CI)	AOR (95% CI)	*p*
PR-born Puerto Rican*	1.90 (1.34–2.70)	1.73 (1.20–2.49)	<0.01
U.S.-born Puerto Rican*	1.04 (0.80–1.35)	1.20 (0.91–1.58)	0.19
Non-Puerto Rican (ref)	1.0	1.0	
Age*	1.07 (1.06–1.09)	1.05 (1.03–1.07)	<0.001
Years drug use*	1.06 (1.05–1.07)	1.03 (1.02–1.05)	<0.001
Prior drug treatment	1.01 (1.00–1.01)	1.00 (1.00–1.01)	0.34
Speedball (sniffed)*	1.50 (1.10–2.04)	1.65 (1.18–2.29)	<0.01
Heroin (sniffed)	1.36 (1.11–1.67)	1.09 (0.86–1.37)	0.48
Cocaine (snorted)*	0.83 (0.68–1.02)	0.78 (0.62–0.97)	<0.05

*Included in the final model after backward elimination.

risk, among U.S.-born Puerto Rican PWID and non-Puerto Rican PWID, respectively). The difference in proportion of seroconversions across ethnicity/birthplace groups among NIDU was not negligible (Fisher's exact $p = 0.051$). Incidence rate among PR-born Puerto Rican NIDU was 18 per 1000 PY at-risk, compared to 1 per 1000 PY at-risk among non-Puerto Ricans (exact binomial $p = 0.06$). The difference in proportion of seroconversions across ethnicity/birthplace groups among NIDU who transitioned to PWID was significant (Fisher's exact $p = 0.01$). Incidence rate among U.S.-born Puerto Ricans was 48 per 1000 PY at-risk, compared to 0 per 1000 PY at-risk among non-Puerto Ricans (exact binomial $p = 0.05$).

Discussion

We observed a much higher prevalence of HCV among both PR-born and U.S.-born Puerto Rican PWID, and among PR-born NIDU than their non-Puerto Rican counterparts. HCV prevalence of 86%, observed among PR-born PWID, was consistent with previous reports of HCV prevalence among PWID in Puerto Rico (Deren et al., 2015; Gelpí-Acosta et al., 2016), and among the highest PWID HCV prevalences in the world (Degenhardt et al., 2017). Similarly, we observed a significantly higher HCV incidence rate among PR-born NIDU and U.S.-born Puerto Rican NIDU who transitioned to injection drug use, compared to their non-Puerto Rican counterparts. Differences in HCV incidence rate across ethnicity/birthplace groups among PWID were not statistically significant, but they were consistent with the pattern observed among NIDU and transitioned groups (i.e. highest HCV incidence rate among PR-born PWID, followed by U.S.-born Puerto Rican PWID, followed by non-Puerto Rican PWID).

These data indicate that Puerto Rican PWUD are at a greater risk of HCV infection. Other investigators have reported that greater proportions of PWID in Puerto Rico or born in Puerto Rico and living in New York engage in injection risk behaviours, such as sharing syringes, than U.S. born PWID (Colón et al., 2001; Deren et al., 2003; Gelpí-Acosta et al., 2016). In our study, however, sharing needles and injection equipment in the past 6 months did not vary across ethnicity/birthplace among PWID in our study. However, PWID are more likely to inject with people of their own race/ethnicity (Momplaisir et al., 2017). In the absence of differences in recent injection risk behaviours, greater risk of HCV infection may be related to greater HCV prevalence in injection networks. We found a greater proportion of Puerto Rican PWID had injected with other Hispanic PWID and that a greater proportion of the former had injected with an HIV positive PWID in the previous 6 months. Both of these observations indicate that Puerto Rican PWID are part of networks with greater risk of infection. Even among NIDU, Puerto Rican participants were more likely to report knowing someone who is HCV positive. The observation of the greater incidence rate of HCV among Puerto Rican PWID and NIDU who transition to injecting drug use also supports the idea that the higher prevalence of HCV in the Puerto Rican PWUD is a critical factor in the

continued elevated risk of HCV infection in this population. In the case of Puerto Rican PWID, there is also the additional factor of frequent travel between Puerto Rico and New York, a phenomenon that has been referred to as 'airbridge' and extensively described by Deren et al. (2007). The mobility of Puerto Rican PWUD on the 'airbridge' between Puerto Rico and New York might put PR-born PWUD at a greater risk (Deren et al., 2007). The higher prevalence of HCV in Puerto Rico and among the Puerto Rican PWID population in U.S. mainland is expected to confer a greater risk of HCV infection to each injection risk behaviour among this population. Therefore, while it is necessary to address injection risk behaviours to prevent HCV transmission, reducing risk behaviours, alone, would not be sufficient to eliminate the HCV epidemic among Puerto Rican PWID – due to the much higher HCV prevalence in this population. Eliminating the HCV epidemic among Puerto Rican PWID, will also require HCV treatment in order to decrease HCV prevalence in this population.

A smaller proportion of PR-born and U.S.-born Puerto Rican PWUD accessed drug treatment and medical services (such as visiting a physician or visiting a hospital emergency room in the past year) than non-Puerto Rican PWUD, implying less opportunity for linkage to HCV care and treatment. The disparity in receiving medical care and drug treatment calls for greater effort to increase access to care among this population.

Providing harm reduction services to PWID, in addition to HCV treatment, is one of the five core intervention areas identified by the WHO (World Health Organization, 2016) in the strategy to eliminate viral hepatitis. Substantial proportions of PWID who were aware of their HCV seropositive status continued to lend their used needles and substantial proportions of PWID who were aware of their HCV seronegative status continued to inject with needles already used by other PWID. Similar proportions of both serostatus groups also continued to share injection equipment. Thus we need more effective intervention strategies to reduce injection risk behaviours. Extensive access to sterile syringes through syringe exchange programs is one such strategy. In our study, those who reported receiving all of their sterile syringes from syringe exchange programs were significantly less likely to inject with used needles from other PWID, and to lend their used needles and syringes to others.

Among NIDU, sharing drug paraphernalia and tattoos (although we did not assess these in our study) may be associated with the risk of HCV infection (Macías et al., 2008). The greater HCV incidence rate and prevalence that we observed among PR-born NIDU in our study may reflect regional disparities in HCV risk. This is consistent with findings of previous studies reporting a greater prevalence of HCV in Puerto Rico than on U.S. mainland (Pérez et al., 2005). The disparity emphasises the need for rectifying regional disparities. U.S.-born Puerto Rican NIDU who transitioned to injection drug use, compared to non-Puerto Ricans, had a significantly greater HCV incidence rate. The HCV incidence rate of PR-born NIDU who transitioned to injection drug use was more than twice that of U.S.-born Puerto Ricans (117 per 1000 PY at-risk vs. 48 per 1000 PY at-risk), yet it was not statistically significantly different than the other two groups. We suggest that the absence of a significant difference in HCV incidence rate of PR-born and the other two groups of participants is most likely due to the small number of the former. The high HCV incidence rates among NIDU who transition to injection drug use highlights the importance of preventing transitioning to injection drug use among NIDU, particularly among Puerto Rican NIDU, who transitioned to injection drug use at more than twice the rate of non-Puerto Rican NIDU.

We note several limitations of this study. One limitation is that participants were not selected as random samples of PWID and NIDU, and we do not intend to generalise the results reported here to the population of PWID and NIDU. Misclassifications due to recall and social desirability, particularly with regards to the stigmatised behaviours we have examined in this study, are also possible. Moreover, differences in the geographic distribution of HCV genotypes/subtypes might have been informative in distinguishing the potential origin of HCV infections among non-Puerto Rican, and PR-born and U.S.-born Puerto Ricans participants (Ruta & Cernescu, 2015), but we did not have the resources to analyse HCV genotypes/subtypes. Finally, the size of our cohort dataset was too small to allow a thorough analysis of the risk factors associated with HCV incidence.

Nevertheless, the finding of greater HCV prevalence among PR-born and U.S.-born Puerto Rican PWUD is consistent with reports of higher HCV rates among immigrants and racial/ethnic minorities in the general population. We have also observed similarly elevated HCV rates among Black PWUD, in comparison to White PWUD (which will be examined in a separate paper). We suggest that the findings of greater HCV incidence and prevalence among Puerto Rican PWUD are sufficient reasons to implement strategies specifically directed to prevention and linkage to care in this population. In March, 2018, the New York State announced the first state-level strategy, in the U.S.A, to end the hepatitis C epidemic (New York Governor's Office, 2018). In New York City, where more than 3 million inhabitants are immigrants, comprising close to 40% of the population of the city (Mayor's Office of Immigrant Affairs, 2018), our findings of greater HCV incidence and prevalence among Puerto Rican participants suggest that eliminating hepatitis C epidemic may entail eliminating hepatitis C epidemics elsewhere, as well.

Our findings support a public health approach to eliminating HCV as a public health threat. PWID constitute the predominant population at risk of HCV infection, and Puerto Rican PWID are at an increased risk of HCV infection. They are also less likely to use the health care delivery system. Therefore, relying on the health care delivery system to find and treat such HCV cases, is likely to be inadequate. Furthermore, the current opioid epidemic is expected to maintain the elevated HCV incidence. The public health approach to HCV, which has already been adopted in New York, offers the best solution (Laraque & Varma, 2017). Nevertheless, unlike the case of HIV treatment, it does not include freely available HCV treatment. The Puerto Rican entrants to drug treatment program in our study are obvious examples of a population with extremely high HCV prevalence who need a public health approach that includes HCV treatment.

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