



Full length article

## Incidence and prevalence of hepatitis c virus infection among persons who inject drugs in New York City: 2006–2013



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### ABSTRACT

**Background:** Hepatitis C virus infection is a source of significant preventable morbidity and mortality among persons who inject drugs (PWID). We sought to assess trends in hepatitis C virus (HCV) infection among PWID from 2006 to 2013 in New York City (NYC).

**Methods:** Annual cross-sectional surveys of PWID entering a large drug abuse treatment program were performed. Risk behavior questionnaires were administered, and HIV and HCV testing were conducted. Comparisons were made with prior prevalence and incidence estimates in 1990–1991 and 2000–2001 reflecting different periods of combined prevention and treatment efforts.

**Results:** HCV prevalence among PWID ( $N = 1535$ ) was 67% (95% CI: 66–70%) during the study period, and was not significantly different from that observed in 2000–2001. The estimated HCV incidence among new injectors (persons injecting for  $\leq 6$  years) during 2006–2013 was 19.5/100 PYO (95% CI: 17–23) and did not differ from that observed in 2000–2001 (18/100 PYO, 95% CI: 14–23/100).

**Conclusions:** Despite the expansion of combined prevention programming between 2000–2001 and 2006–2013, HCV prevalence remained high. Estimated HCV incidence among new injectors also remained high, and not significantly lower than in 2000–2001, indicating that expanded combined prevention efforts are needed to control the HCV epidemic among PWID in NYC.

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### 1. Introduction

Hepatitis C virus (HCV) infection is a major source of preventable morbidity and mortality among persons who inject drugs (PWID), among whom HCV is hyperendemic (Hagan, 2011; Ly et al., 2012). HCV is readily transmissible via non-sterile injections (Hagan, 2011). Its transmissibility, combined with a high population prevalence among PWID (estimated at 43–67% among lifetime PWID; Armstrong et al., 2006; Lansky et al., 2014; World Health Organization, 2014), and a high prevalence of drug injection behaviors that facilitate transmission (e.g., 30% rates of receptive syringe sharing; Des Jarlais et al., 2010), leads to situations of high annual

incidence of HCV infection (Backmund et al., 2005; Hagan, 2011; Ly et al., 2012; Wiessing et al., 2014).

Nonsterile iatrogenic nosocomial injection-related transmission, and other healthcare-related exposures, have been greatly reduced in settings where infection control practices and screening of blood and organ products have been implemented (Averhoff et al., 2012; Backmund et al., 2005); in these settings nonsterile illicit drug injection is the predominant mode of HCV transmission (Alter, 2011b). HCV epidemics became established in populations of PWID in the 1960s to 1990s, preceding and exceeding the epidemic of HIV and leading to high prevalence epidemics in many cities (Alter, 2011a; Nelson et al., 2011). In New York City (NYC) in the 1990s, approximately 80–90% of PWID were HCV infected and 50% were HIV infected (Des Jarlais et al., 2005b).

In the period from the mid-1990s to the mid-2000s, a number of interventions were developed and implemented in an attempt to prevent blood borne pathogen transmission via non-sterile injections (Des Jarlais et al., 2009a, 2005b; Hagan et al., 2011). We have previously shown that the expansion of combined prevention

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programming with continued medication assisted treatment (MAT) of opioid dependence (e.g., methadone maintenance), expanded needle and syringe exchange programs (SEPs), and the introduction of anti-retroviral therapy (ART) were temporally associated with very significant reductions in HIV prevalence and incidence among PWIDs in NYC (Des Jarlais et al., 2005a). During the same period of initial combined prevention, HCV prevalence decreased from 91% to 62% among PWID, while the incidence of HCV infection among new injectors (persons who began injecting within the prior 6 years) remained quite high (estimated as 18/100 person years of observation (PYO) in 2000–2001; Des Jarlais et al., 2010, 2005b).

Since that time there has been a continued expansion of combined HIV and HCV prevention efforts, which has included evolving and improving treatment for HCV, as well of efforts at HCV education and testing, and changes in community level awareness of HCV (Gow and Mutimer, 2001; Heller and Paone, 2011; Tesoriero et al., 2009); however, there was not an expansion of HCV treatment among PWID comparable to the expansion of ART treatment of HIV among PWID (Grebely and Dore, 2014; Des Jarlais et al., 2015; Wiessing et al., 2014). Concurrent with these expanded combined prevention efforts, there was a continued decline in HIV incidence and prevalence among PWID (Des Jarlais et al., 2010, 2015), but the impact on HCV incidence and prevalence among PWID in NYC has not been characterized.

We now extend previous observations to examine HCV prevalence and incidence among PWID in NYC in the period 2006–2013 and compare these with data from 1990–1991 and 2000–2001 collected with the same methods (Des Jarlais et al., 2005b). We hypothesized that due to the higher infectivity of HCV compared to HIV, and to the less extensive implementation of antiviral treatment for HCV than for HIV among PWID, that the impact of combined prevention programming on HCV incidence and prevalence might be less than the impact observed on HIV incidence and prevalence. The specific objectives include (1) estimating HCV prevalence among PWID, (2) estimating HCV incidence among new injectors in NYC and (3) comparing HCV prevalence, and estimated incidence among new injectors, who began injecting during different time periods reflecting the availability of different combined prevention public health efforts.

## 2. Methods

### 2.1. The Risk Factors study

The data reported here are derived from ongoing analyses of data collected from drug users entering the Mount Sinai Beth Israel (MSBI) drug detoxification and methadone maintenance treatment program (MMTP) in NYC. The methods have been previously described in detail (Des Jarlais et al., 2000, 2009a, 1989, 1994, 2005b). This paper presents new analyses on data from participants recruited from 2006, when HCV testing became a routine part of the “Risk Factors” study, through to 2013. While survey methods did not change between 1990 and 2013, recruitment at MMTP was added to recruitment at detoxification in 2010. There have been no changes in the requirements for entrance into the drug treatment programs over the study time. Participants in both the MMTP and the detoxification program are opioid users who may use opioids by different routes (injecting, intra-nasal use or smoking), either exclusively or in different proportions.

The MSBI detoxification program has 5000–6000 admissions per year and serves primarily NYC residents, with approximately half of its patients living in Manhattan, one quarter in Brooklyn, one-fifth in the Bronx, and the remainder (i.e., 5%) living elsewhere. The MMTP is also large, serving approximately 6000 patients at any one time. Patients enter both programs voluntarily. For these analyses, we included persons who reported *ever* having injected drugs, henceforth referred to as PWID. This study was approved by the MSBI institutional review board.

### 2.2. Study recruitment

**Detoxification program:** Persons entering the detoxification program are assigned to different wards depending upon available beds. Research staff visited the wards of the detoxification program on randomly selected days, in a preset order, and examined all intake records of a specific ward to construct lists of patients

admitted within the prior three days. All of the patients on the list for the specific ward were then asked to participate in the study; the participation rate has been more than 95% in any given year. After all the patients admitted to a specific ward in the three-day period had been asked to participate and interviews conducted among those who agreed to participate, the interviewers moved to the next ward in the preset order. Because there was no relationship between the assignment of patients to wards and the order that the staff rotated through the wards, these procedures should produce an unbiased sample of persons entering the detoxification program.

**MMTP:** Patients were recruited for study participation during the intake process at the MSBI MMTP. Participants were asked to participate simply in the order in which they came for intake processing each day. Willingness to participate in the study was also high in the MMTP, with over 95% of those asked agreeing to participate in the study.

At both the detoxification program and MMTP, participants were permitted to participate in the study multiple times, though only once per year. All data from participants who were interviewed in different years were used in the analyses as those participants were members of the population of interest in the different years. Approximately 3% of participants in any given year were repeat participants. The design of the study is thus a series of annual cross-sectional surveys of persons who received drug treatment at the MSBI detoxification and MMTP.

### 2.3. Study methods

After informed consent was obtained, study participants completed a structured questionnaire administered by a trained interviewer covering demographic, drug use and drug use behaviors (including related to drug injection), sexual risk behavior, and the use of HIV and HCV prevention and other medical services. Participants were asked to report risk behaviors in the previous six months.

After questionnaire completion, participants underwent counseling and testing for HIV and HCV and HSV-1/2 antibodies. HCV testing was conducted using an Ortho HCV enzyme immunoassay 4.0. In this paper, HCV seropositivity and seronegativity refers to the presence or absence of anti-HCV antibodies; HCV viral load testing was not routinely conducted as part of the study.

### 2.4. HCV prevalence estimates

HIV and HCV prevalence were calculated among persons who had ever injected drugs (PWID); prevalence was examined among those who had ever, rather than recently, injected drugs, since ever having injected drug confers risk for both HIV and HCV. Prevalence data were calculated for all PWID, HIV-negative PWID, and HIV-positive PWID by recruitment year and recruitment site and compared with those of 1990–1991 and 2000–2001 (Des Jarlais et al., 2005b). Individuals who participated more than once constitute <3% of the cohort; they are included in prevalence estimates for any given years in which they participated, as they constitute part of the prevalent population of PWID.

### 2.5. HCV incidence estimates

Since the dataset includes detailed information on both year of initiation of drug injection and years of injection drug use, cohorts were constructed of PWID who initiated or engaged in drug injection during different time frames. *Newly initiated drug injection* was defined as having initiated drug injection within the 6 years preceding the date of the study interview; *current drug injection* was defined as having injected ( $\geq$ once) in the past 6 months. These time frames were chosen to be consistent with previous analyses (Des Jarlais et al., 2005b). As a serial cross sectional study, any individuals who participated more than once (<3% of the cohort) would be included in estimates of incidence in each year in which they are recruited.

We have previously shown that transition from injecting to noninjecting drug use is associated with reductions in HCV (Des Jarlais et al., 2014b); we therefore focused estimates of HCV incidence on newly initiated PWID who were also current injectors (i.e., who had initiated injection in the past 6 years and who had injected in the 6 months prior to the study interview and testing; hereafter referred to as *new injectors*) to enhance ascertainment of the time at risk. We further restricted incidence estimates to HIV-negative new injectors both because virtually all HIV-infected new injectors were HCV infected, and to be consistent with the previous published paper (Des Jarlais et al., 2005b) and allow direct comparisons. We estimated HCV incidence among all HIV-negative new injectors recruited in the 2006–2013 period and separately, among new injectors in each recruitment year. The incidence among new injectors enrolled during this time period was compared to those enrolled in 2000–2001.

### 2.6. Assumptions for incidence analyses

Analyses rely on several key assumptions including: (1) that all participants were HCV negative when they started injecting; (2) that HCV seropositive participants had seroconverted to HCV at the midpoint between initiation of drug injection and time of first study interview (thus that the numerator for incidence estimates included the total number of HCV positive participants and the denominator included the total number of injecting years for those HCV negative and half

the total number of years injecting for those HCV positive); (3) that there were no differential losses of those HCV positive versus those HCV negative in the PWID population; and (4) those who reported having initiated injection <1 year prior to the study interview were assumed to have injected for 0.5 year and the same calculations were performed.

### 2.7. HCV prevalence and incidence among PWID who began injecting during different environments of combined prevention programming

We examined HCV prevalence among PWID and estimated incidence among new injectors enrolled in the 2006–2013 time period. Previous analyses examined HCV prevalence among PWID recruited in 1990–1991 and 2000–2001 and examined estimated HCV incidence among new injectors in 2000–2001 using stored sera (Des Jarlais et al., 2005b). PWID recruited in 1990–1991 would have begun injecting during a period of limited prevention programming (prior to 1994). New injectors recruited in 2000–2001 would have begun injecting during a period of initial combined prevention programming (1995–2000), while those recruited during 2006–2013 would have begun injecting during a period of more expanded combined prevention programming (2001–2013):

*Prior to 1994: Limited prevention programming:* In NYC, MMTP was implemented on a large scale in the 1960s/70s, before the HIV epidemic (Des Jarlais et al., 2014a). During this period there was large-scale provision of MMTP (approximately 50,000 treatment positions); by 1990 there was limited syringe exchange (approximately 250,000 syringes exchanged per year; Des Jarlais et al., 2005a); HIV counseling and testing, sexual risk reduction education and some condom distribution were provided at substance use treatment programs.

*1995–2000: Initial combined prevention programming:* During this period, there was implementation of large-scale SEPs (with exchange of 2 to 3 million syringes per year). The expansion of SEPs during this period was associated with large decreases in HIV incidence and prevalence among PWID, and some reduction in HCV incidence among PWID but incidence remained high (Des Jarlais et al., 2005b). Prior to 1998, HCV treatment included interferon only; in 1998, HCV treatment became a dual treatment regimen of both interferon and ribavirin (Gow and Mutimer, 2001). In 1997, the NIH management of HCV consensus statement that people who use illicit drugs should not be offered HCV treatment until they abstain from drug use for 6 months (National Institutes of Health, 1997). This was reiterated and reinforced through a MMWR CDC publication on HCV in 1998 (Centers for Disease Control, 1998).

*2001–2013: Expanded combined HCV prevention programming:* During this period, MMTP and SEP prevention programming continued but did not expand, and pharmacy sales of sterile injection needles and syringes was begun (Tesoriero et al., 2009). In 2001 New York State (NYS) authorized the sale of sterile injecting equipment by pharmacies participating in an Expanded Syringe Access Program (ESAP; Tesoriero et al., 2009). The program grew to include many pharmacies and spatial access to participating pharmacies increased (Cooper et al., 2009, 2011; Crawford et al., 2014; Heller and Paone, 2011). Pegylated interferon was introduced in 2001–2002. The NIH Consensus Statement on the Management of HCV was revised in 2002 with a recommendation that PWID should be offered treatment on a case-by-case basis (National Institutes of Health, 2002). During 2011–2013 there was FDA-approval and market release of the first two protease inhibitors for the treatment of HCV; and there was an expansion of public health efforts to address HCV in NYC and elsewhere, including the Check Hep C program (Jordan et al., 2012). Some efforts to link HCV infected PWID from MMTP to care were initiated (Masson et al., 2013) and in 2011 the MSBI MMTP began routine HCV testing. However, in NYC as elsewhere, very few PWID were treated for HCV during this time (Aspinal et al., 2013; Grebely et al., 2008; Linas et al., 2014).

These historical periods provide an important aid in understanding the progressive implementation of multiple HCV prevention and treatment programs for PWID in NYC (Des Jarlais et al., 2009a, 2009b, 2005b).

### 2.8. Data analysis

SPSS 22.0 (IBM Corp.; Armonk, NY, USA) was used for statistical analyses. HCV prevalences were calculated with 95% binomial confidence intervals calculated around relevant proportions. Chi-squared correlations and corresponding *p*-values were used to compare HCV prevalence by year and to test for trends.

## 3. Results

Between 2006 and 2013 a total of 4100 participants were recruited into the “Risk Factors” study. The proportion reporting a history of ever drug injection (i.e., current or former drug injection) increased significantly over the 2006–2013 study period from 35.6% (224 of 630) to 51.8% (248 of 478; *p*-value for trend: <0.0001) for a total of 1774 PWID recruited during this study period. Two hundred and eleven (11.9%) did not have HIV data available, 87% of whom did not have HCV data available; 213 (12%) PWID did not

have HCV data available, 88% of whom did not have HIV data available. Complete HIV and HCV data were available for 1535 of 1774 PWID.

Table 1 presents characteristics of these 1535 PWID study participants. The mean age of initiation of drug injection was 24.4 years (SD: 8.3). Approximately half (*N*: 766; 50.5%) reported initiating drug injection in 1995 or after (see Table 1). HIV prevalence among PWID recruited between 2006 and 2013 was 11.9% (183 of 1535; 95% CI: 10–14%). There was a statistically significant decrease in HIV prevalence over the 2006–2013 study period (from 17% to 4.3%; *p*-value for trend: <0.0001).

HCV prevalence among these 1535 PWID was 68.2% (1047 of 1535; 95% CI: 66–70%). PWID recruited at MMTP in 2011–2013 did not differ significantly from those recruited at detoxification with respect to age, gender, age at first injection, the proportion who were currently injecting, or the proportion who were newly initiated injectors; PWID recruited at MMTP were more likely to be non-white than those recruited at detoxification (74% versus 64%, *p*=0.006). Table 2 depicts HCV prevalence among PWID by recruitment site in each of the study years.

There were modest, but not significant, decreases in HCV prevalence among HIV-negative PWID recruited at detoxification between 2006 and 2013 (*p*-value: 0.09) and among HIV-negative PWID recruited at MMTP (2011–2013) (*p*-value: 0.19). There was no change in HCV prevalence among HIV-positive PWID recruited at detoxification between 2006 and 2013 (*p*-value: 0.85) or among HIV-positive PWID recruited at MMTP between 2011 and 2013 (*p*-value: 0.52) (see Table 2). HCV prevalence among all PWID recruited at the detoxification program significantly decreased over the 2006–2013 study period from 76% to 59% (*p*-value for trend: 0.009); there was a concurrent significant decrease in the proportion of PWID recruited at the detoxification program who were HIV-infected over the same eight year period (test for trend *p*=0.001; Table 2) from 16.9% in 2006 to 3.4% in 2013.

Table 3 depicts the HCV prevalence among all PWID, HIV-negative PWID, and HIV-positive PWID recruited at detoxification between 2006 and 2013 and compares them with the HCV prevalence previously found in these groups among those recruited in 1990–1991 and 2000–2001. While HCV prevalence decreased among all PWID between 1990–1991 and 2000–2001 as previously reported, (Des Jarlais et al., 2005b) the HCV prevalences among all PWID, HIV-negative PWID and HIV-positive PWID in 2006–2013 do not differ from those identified in 2000–2001.

There were 395 newly initiated PWID recruited between 2006 and 2013, of whom 347 were current PWID. Of these 347 new injectors, 141 were HCV seropositive (41%; 95% CI: 36–46%). The estimated incidence of HCV among these new injectors in each recruitment year is depicted in Table 4. Overall, the estimated incidence of HCV among new injectors during the study period was 19.5/100 PYO (95% CI: 17–23). This estimated HCV incidence among new injectors did not differ from the estimated incidence in 2000–2001 of 18/100 PYO (95% CI: 14–23/100 PYO). There was no significant difference in estimated HCV incidence among new injectors in each year of study recruitment (Table 4).

Of the 347 new injectors, 73% reported injecting at least once daily in the past 6 months; the proportion doing so did not change over the 2006–2013 study period (test for trend over time *p*=0.31). Sixty eight percent reported obtaining none of their needles and syringes from an SEP in the past 6 months; this proportion did not change over the study period (*p*=0.22). Twenty seven percent reported sharing a cooker at least once in the past 6 months; this proportion did not change over the study period (*p*=0.65). Twenty five percent reported at least 1 instance of injection with a syringe previously used by someone else in the past 6 months; this proportion did not change over the study period (*p*=0.5). Ninety-one percent (*N*=331) of the new injectors were recruited from

**Table 1**  
Demographic characteristics of HIV-negative and HIV-positive PWID tested for HCV from 2006 to 2013 in New York City.

Variable	N and % of total PWID <sup>a</sup>		N and % of HIV-negative PWID <sup>a</sup>		N and % of HIV-positive PWID <sup>a</sup>	
	N = 1535		N = 1352		N = 183	
Age (in yrs; mean (SD))	41.2	10.1	42.3	9.1	44.6	7.5
Race/ethnicity		(N = 1482)		(N = 1304)		(N = 178)
White	427	28.8	406	31.1	21	11.8
Black	359	24.2	276	21.2	83	46.6
Latino/a	696	47.0	622	47.7	74	41.6
Gender						
Male	1256	82.0	1114	82.4	142	79.2
Female	275	18.0	235	17.1	40	24.6
Age first used illicit drugs (in yrs; mean (SD))	18.0	5.4	20.1	6.8	20.1	6.8
Age first injected drugs (in yrs; mean (SD))	24.4	8.3	24.7	8.4	21.9	7.6
Current PWID (injected within previous 6 min)	1195	77.9	1071	80.2	124	67.8
Newly initiated PWID (drug injection initiated within previous 6 yr)	395	25.7	376	27.8	19	10.4
Time periods of injection initiation						
Pre-1995	769	49.9	616	81.1	144.0	18.9
1995–2000	269	17.5	252	1.9	22	12.0
2001–2006	268	17.5	256	18.9	17	9.3
2006–2010	156	10.2	149	11.0	8	4.4
2011–2013	73	4.8	70	5.2	3	1.6
Recruitment site						
Detox	1328	86.8	1165	87.4	163	93.4
MMTP	202	13.2	184	14.1	18	11.0
Ever heard of HCV	1304	97.4	1163	N = 1196 97.2	N = 143 141	98.6
Ever received an HCV test	1080	87.8	949	N = 1091 88.0	131	N = 139 94.2
Anti-HCV positive	1047	69.3	888	65.7	159	86.9

<sup>a</sup> For categorical variables, percentages are of the total N in each column heading except when noted by a total N listed above a given variable. Where missing responses are >10% of total responses, the N is given.

<sup>b</sup> N and percentage given unless otherwise noted.

**Table 2**  
Prevalence of HCV among PWID in NYC by year and recruitment site.

	Overall		HIV-negative		HIV-positive	
	N HCV+/N PWID	HCV prevalence	N HCV+/N PWID	HCV prevalence	N HCV+/N PWID	HCV prevalence
2006						
Detoxification	156/206	76%	125/171	73%	31/35	89%
2007						
Detoxification	118/161	73%	88/128	69%	30/33	91%
2008						
Detoxification	128/181	71%	109/159	69%	19/22	86%
2009						
Detoxification	104/156	67%	91/140	65%	13/16	81%
2010						
Detoxification	106/161	66%	83/135	61%	23/26	88%
2011						
Detoxification	90/144	63% <sup>b</sup>	78/128	61% <sup>d</sup>	12/16	75% <sup>f</sup>
MMTP <sup>a</sup>	38/47	81%	31/39	79%	7/8	88%
2012						
Detoxification	105/171	61% <sup>c</sup>	97/161	60% <sup>e</sup>	8/10	80% <sup>f</sup>
MMTP	70/95	74%	64/89	72%	6/6	100%
2013						
Detoxification	88/148	59% <sup>f</sup>	84/143	59% <sup>f</sup>	4/5	80% <sup>f</sup>
MMTP	39/60	65%	35/56	63%	4/4	100%

<sup>a</sup> Risk Factors initiated recruitment in MMTP in 2010 thus, data are only available for years 2011–2013.

<sup>b</sup> p-Value = 0.02 for the comparison of HCV prevalence between detoxification and MMTP in this year.

<sup>c</sup> p-Value = 0.04 for the comparison of HCV prevalence between detoxification and MMTP in this year.

<sup>d</sup> p-Value = 0.03 for the comparison of HCV prevalence between detoxification and MMTP in this year.

<sup>e</sup> p-Value = 0.07 for the comparison of HCV prevalence between detoxification and MMTP in this year.

<sup>f</sup> p-Value > 0.2 for the comparison of HCV prevalence between detoxification and MMTP in this year.

**Table 3**  
Prevalence of HCV among PWID in NYC in detoxification (1990–1991, 2000–2001, and 2006–2013).

	1990–1991	2000–2001	2006–2013
Prevalence of HCV/total HIV-negative PWID No. of HCV-negative/no. of HIV-negative Percentage (95% CI)	20/25 80% (59%, 93%)	200/340 59% (53%, 64%)	755/1165 <sup>a,b</sup> 65% (62%, 68%)
Prevalence of HCV/total HIV-positive PWID No. of HCV-positive/no. of HIV-positive Percentage (95% CI)	44/44 100%	58/71 82% (71%, 90%)	140/163 <sup>c,d</sup> 86% (79%, 90%)
Prevalence of HCV among all detox PWID (95% CI)	91% (83%, 98%)	62% (58%, 67%)	67% (65%, 70%)

<sup>a</sup> *p*-Value = 0.11 for the comparison of 2006–2013 and 1990–1991.

<sup>b</sup> *p*-Value = 0.04 for the comparison of 2006–2013 and 2000–2001.

<sup>c</sup> *p*-Value = 0.008 for the comparison of 2006–2013 and 1990–1991.

<sup>d</sup> *p*-Value = 0.41 for the comparison of 2006–2013 and 2000–2001.

**Table 4**  
Estimated incidence of HCV infection among HIV-negative newly initiated current PWID, 2006–2013.

Study year	No. of newly initiated current PWID	No. of newly initiated current PWID with HCV infection	Person-years at risk	Incidence per 100 person-years	95% confidence interval
<i>Overall (2006–2013)</i>	347	141	724.00	19.50	(17%, 23%)
2006	63	31	138.50	22.40	(16%, 30%)
2007	32	16	49.75	32.10	(21%, 46%)
2008	29	11	77.25	14.20	(8%, 24%)
2009	33	15	62.75	23.90	(15%, 36%)
2010	19	4	52.50	9.50	(3%, 18%)
2011	44	14	94.00	14.90	(9%, 23%)
2012	64	31	126.25	24.60	(18%, 33%)
2013	63	19	123.00	15.40	(10%, 23%)

detoxification, only 15% of whom had received any methadone maintenance in the past month; this proportion did not change over the study period ( $p = 0.42$ ).

#### 4. Discussion

These data demonstrate that the HCV prevalence among PWID and the estimated HCV incidence among new injectors both remain high in NYC. During the 2006–2013 study period of combined prevention programming HIV prevalence among PWID decreased significantly, yet current prevention strategies have not led to comparable reductions in HCV prevalence or estimated incidence among new injectors.

These data strongly suggest an ongoing, high prevalence HCV epidemic among PWID in NYC. While these data are based on HCV antibody data, there is no reason to suspect any change in the proportion of those clearing HCV infection and hence the persistent high HCV prevalence also suggests a continued high HCV community viral load. The estimated incidence of HCV among new injectors remained high (19.5/100 PYO) and was not significantly different than that we observed in 2000–2001 (18/100 PYO, 95% CI = 14–23) (Des Jarlais et al., 2005b). These incidence estimates are consistent with recent estimates among young current PWID recruited in San Francisco in 2000–2013 (Tsui et al., 2014). However, reductions in HCV incidence have been observed in some other settings (e.g., Australia and Vancouver, Canada), in association with expansions of SEP and MAT prevention programming, reductions in syringe borrowing, but in at least in instance, in association with increases in crack cocaine use (Grebely and Dore, 2014; Iversen et al., 2013; White et al., 2014).

The expanded combined prevention programming in NYC during the 2006–2013 period included multiple interventions with the potential to reduce the incidence and prevalence of both HIV and HCV (e.g., MAT, SEP, ESAP, and more effective antiviral treatment options) as well as additional programs with the potential to impact HIV transmission (e.g., the NYC Condom program and expanded use of ART among PWID and hence, HIV TasP; Des Jarlais et al., 2015). As previously reported, HIV prevalence and incidence declined

substantially among PWID during this period (Des Jarlais et al., 2009a, 2010).

In contrast, while the expanded combined prevention programming in NYC during this time period did include several interventions with the potential to impact HCV transmission (MAT, SEP, ESAP, as well as significantly improved HCV treatment options), we did not observe any significant decrease in HCV prevalence or incidence. During this period, PWID in general, and new injectors in particular, had incomplete access to or engagement in MAT (there was no additional expansion of MAT during this period and most PWID were not consistently in MAT) and the majority had incomplete sterile needle and syringe coverage (whether through SEP and/or ESAP), many of the new injectors engaged in some form of non-sterile injection, and the overwhelming majority were not receiving MAT (in the 6 months prior to entry into the study), even in this cohort recruited in drug treatment settings. HCV is more readily transmitted by non-sterile injection practices than is HIV (Alter, 2006; Hagan, 2011); hence, the impact of any degree of sterile needle, syringe, and drug preparation equipment (“drug injection equipment”) access is likely to have less of an effect on HCV transmission than on HIV transmission. Therefore, degrees of MAT and sterile drug injection equipment access sufficient to contribute to effective HIV combination prevention programming may be insufficient for effective HCV prevention programming.

Another important difference between the expanded combined prevention programming implemented during this period with respect to HCV and to HIV transmission is the extent of antiviral treatment coverage implemented for the two infections. While the NIH consensus statement of 2002 suggested that PWID should be offered HCV treatment on a case by case basis (National Institutes of Health, 2002), during this period, very few PWID initiated or completed HCV treatment (Aspinall et al., 2013; Linas et al., 2014; Mehta et al., 2006). While data regarding the potential for HCV treatment to function as HCV treatment as prevention are unclear, what is clear is that there is no potential for it to do so if HCV-infected PWID are not treated. Modeling suggests that a significant scale up of HCV treatment would be necessary to reduce HCV prevalence by three-quarters within 15 years (Martin et al., 2013). While

specific data for NYC are not available, there have continued to be very significant gaps in the HCV continuum of care for PWID in most regions including NYC, with few individuals being linked to and engaged in HCV treatment; recent estimates are that only 1–9.5% of HCV infected PWID initiate treatment (Grebely and Dore, 2014; Wiessing et al., 2014). The more widespread implementation of effective linkage to care models will be needed for HCV treatment as prevention to impact the ongoing HCV epidemic among PWID in NYC (Jordan et al., 2012; Masson et al., 2013). While our data cannot quantify the contribution of the impact of gaps in MAT coverage, sterile drug injection equipment access or HCV treatment to the failure of combined prevention programming to reduce HCV incidence during this period, the data clearly demonstrate that more potent combined HCV prevention programs are needed.

Modeling has suggested that the ability of HCV treatment as prevention to impact the HCV epidemic among PWID, and to do so cost-effectively, is reduced when the HCV prevalence is approximately 60% (Martin et al., 2012), as was found among PWID in NYC in our study. While estimates of approximate levels of MAT, SEP and TasP coverage that may be required to reduce HCV incidence among PWID in NYC are needed, these findings, combined with the identified gaps in access to sterile syringes, suggests that HCV control among PWID in NYC is likely to require some expansion of MAT and/or sterile drug injection equipment access in concert with treatment as prevention.

This study has limitations. While participants were selected randomly from among detoxification and MMTP entrants, there is a potential for selection bias with respect to representativeness of PWID in NYC; however, neither the number of detoxification or MMTP treatment slots, nor their admission criteria, changed significantly during the study period. Measures of HCV prevalence relied on HCV antibody testing; while HCV viral loads were not done, there is no substantive reason to suspect that rates of HCV clearance would differ from those generally observed, or that they would change over the periods of study and comparison. As the study is a series of annual cross-sectional surveys, direct data on HCV seroconversion were not available. The incidence estimates relied on several key assumptions. PWID were assumed to have been HCV negative when they started injecting; were this not the case, estimates of HCV incidence might have been lower. If there were greater differential loss of HCV positive PWID compared with HCV negative PWID in the study population, estimates of HCV incidence might have been higher. However, the assumptions made for incidence estimates in both the 2000–2001 and 2006–2013 time periods were the same, and the incidence estimates we found are consistent with other recent data from San Francisco (Tsui et al., 2014). Both to allow direct comparison with our previous study and to afford more robust incidence estimates, we defined recent injection initiation as being within the past 6 years; however, comparative data on incidence during the first several years of injection would be valuable. Individuals who were included in the study more than once would have been included in prevalence estimates in each year they were included; this in fact provides an accurate measure of HCV prevalence. Since such persons represent <3% of the cohort, their inclusion is not likely to impact incidence estimates. Incidence estimates include new injectors recruited from both MMTP and detoxification; including MMTP participants, who might be expected to be at lower risk of HCV acquisition, could lead to underestimates of HCV incidence, both in general, and in comparison with our 2000–2001 data which did not include new injectors recruited from MMTP (Des Jarlais et al., 2005b). We examined trends in HCV prevalence and incidence in temporal relation to changes in combined prevention programming; relationships between these two cannot with certainty be inferred to be causal. Nonetheless, use of historical periods – prior to and after implementation of interventions – is a common method for studying changes over

time in epidemics (Des Jarlais et al., 2009a, 2009b, 2010, 2005b, 2015).

In conclusion, there continues to be a high prevalence of an HCV epidemic among PWID in NYC. New injectors in NYC remain at high risk for HCV. More potent combined prevention, including significant scale up of some combination of MAT, sterile drug injection equipment access, and HCV treatment is urgently needed to control the HCV epidemic among PWID in NYC.

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## Contributors

A.E. Jordan, D.C. Des Jarlais and D.C. Perlman conceptualized the current study and analyses. D. C. Des Jarlais originated the risk factors study and supervised all aspects of its implementation and the implementation of these analyses. A.E. Jordan conducted the analyses and wrote the first draft of the article, and K. Aresteh and assisted with the analyses. D. C. Perlman, K. Aresteh, C. McKnight and D. Nash assisted with the study and writing. All of the authors helped to conceptualize the idea, interpret findings, and review drafts of the article.

## Conflict of interest

No conflict declared.

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