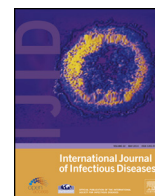


Contents lists available at [ScienceDirect](http://ScienceDirect.com)

International Journal of Infectious Diseases

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

Dual sexual and drug-related predictors of hepatitis C incidence among sex workers in a Canadian setting: gaps and opportunities for scale-up of hepatitis C virus prevention, treatment, and care



Shira M. Goldenberg^{a,b,*}, Julio Montaner^{a,c}, Melissa Braschel^a, Eugenia Socias^{a,c},
Silvia Guillemi^{a,c}, Kate Shannon^{a,c}

^a British Columbia Centre for Excellence in HIV/AIDS, St. Paul's Hospital, 608–1081 Burrard Street, Vancouver, BC, V6Z 1Y6, Canada

^b Faculty of Health Sciences, Simon Fraser University, Burnaby, BC, Canada

^c Department of Medicine, University of British Columbia, St. Paul's Hospital, Vancouver, BC, Canada

ARTICLE INFO

Article history:

Received 20 September 2016

Received in revised form 14 December 2016

Accepted 16 December 2016

Corresponding Editor: Eskild Petersen, Aarhus, Denmark

Keywords:

Hepatitis C

HIV

Sexually transmitted infections

Sex work

SUMMARY

Background: Hepatitis C virus (HCV) represents a significant cause of morbidity and mortality globally. While sex workers may face elevated HCV risks through both drug and sexual pathways, incidence data among sex workers are severely lacking. HCV incidence and predictors of HCV seroconversion among women sex workers in Vancouver, BC were characterized in this study.

Methods: Questionnaire and serological data were drawn from a community-based cohort of women sex workers (2010–2014). Kaplan–Meier methods and Cox regression were used to model HCV incidence and predictors of time to HCV seroconversion.

Results: Among 759 sex workers, HCV prevalence was 42.7%. Among 292 baseline-seronegative sex workers, HCV incidence density was 3.84/100 person-years (PY), with higher rates among women using injection drugs (23.30/100 PY) and non-injection crack (6.27/100 PY), and those living with HIV (13.27/100 PY) or acute sexually transmitted infections (STIs) (5.10/100 PY). In Cox analyses adjusted for injection drug use, age (hazard ratio (HR) 0.94, 95% confidence interval (CI) 0.86–1.01), acute STI (HR 2.49, 95% CI 1.02–6.06), and non-injection crack use (HR 2.71, 95% CI 1.18–6.25) predicted time to HCV seroconversion.

Discussion: While HCV incidence was highest among women who inject drugs, STIs and the use of non-injection stimulants appear to be pathways to HCV infection, suggesting potential dual sexual/drug transmission. Integrated HCV services within sexual health and HIV/STI programs are recommended. © 2017 The Authors. Published by Elsevier Ltd on behalf of International Society for Infectious Diseases. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Hepatitis C virus (HCV) represents a significant and rising global public health issue, with 185 million people estimated to be living with HCV.^{1,2} Most persons living with HCV are chronically infected, which poses a high risk for the development of liver cirrhosis, liver cancer, and chronic liver disease.² In May 2016, the first-ever global hepatitis targets were adopted by the World Health Assembly, galvanizing attention for this previously under-recognized and relatively neglected health priority. These include reducing new viral hepatitis infections by 90% and reducing deaths due to viral

hepatitis by 65% by 2030, supporting increasing calls for scaling-up access to HCV prevention, treatment, and care.³

HCV is known to disproportionately affect marginalized and underserved populations, primarily people who inject drugs (PWID),^{4–6} and to a lesser extent, men who have sex with men (MSM).^{5,7} Although research on HCV among people who use non-injection drugs has recently increased, little remains known regarding HCV incidence among other key populations, particularly sex workers, who face potentially elevated risks due to dual drug and sexual transmission pathways. While little is known about HCV among sex workers, this population faces a greatly elevated burden of HIV, sexually transmitted infections (STIs), and other sexual- and drug-related harms. These harms have been primarily attributed to structural factors, including violence, unsafe working conditions, stigma, and criminalization, which

* Corresponding author. Tel.: +1 604 558 6678; fax: +1 604 806 9044.
E-mail address: gshi-sg@cfenet.ubc.ca (S.M. Goldenberg).

undermine the negotiation of sexual and drug risk mitigation,^{8,9} as well as access to health and harm reduction services.^{10,11}

Among a small body of research on HCV among sex workers from non-endemic settings such as Estonia,¹² Argentina,¹³ and South Korea,¹⁴ HCV prevalence has been found to be consistently higher than in the general population, ranging from 1.4% among sex workers in South Korea to 7.9% in Estonia. Although few studies have assessed predictors of HCV incidence or prevalence among sex workers, previous work suggests that sex workers who are street-involved, criminalized, use drugs, and engage in syringe-sharing are particularly vulnerable to HCV.^{15,16} Amidst global calls for HCV treatment scale-up for key populations and the rising availability of new and highly effective direct-acting antiviral (DAA) treatments for HCV, addressing the gap in epidemiological data regarding the incidence and prevalence of HCV among sex workers remains of paramount importance.

In Metropolitan Vancouver, British Columbia (BC), women sex workers face a disproportionate burden of HIV (with an estimated prevalence of 12%),^{8,17} elevated sexual- and drug-related harms,^{18,19} and structural barriers to HIV and harm reduction services.^{8,10,11} Due to advances in HCV treatments, current efforts to scale up HCV treatment are currently being explored in BC, particularly for key populations facing intersecting harms related to substance use disorders, HIV, and HCV. Given evidence suggesting the potential for dual sexual and drug risk pathways for HCV acquisition, particularly within the context of sex with multiple partners, and the current dearth of HCV incidence data among sex workers, this study aimed to characterize the incidence and predictors of HCV infection among sex workers in Metropolitan Vancouver, BC.

Methods

Data collection

Data were drawn from An Evaluation of Sex Workers' Health Access (AESHA), a prospective cohort of over 800 women sex workers recruited through street, indoor, and online outreach across Metropolitan Vancouver from January 2010 to August 2014. AESHA is based on collaborations with sex work agencies that have existed since 2005 and is monitored by a community advisory board of more than 15 organizations. The study was approved by the Providence Health Care/University of British Columbia Research Ethics Board.

As used previously,¹⁷ eligibility criteria included self-identifying as a woman (transgender male-to-female inclusive), age ≥ 14 years, exchanged sex for money within the last month, and provided informed consent. The sample size was calculated to detect associations between structural determinants of primary interest (e.g., work environments, policing) and HIV/STI incidence. Time–location sampling was used to recruit participants through weekly outreach to street, indoor, and online venues across Metropolitan Vancouver, which were identified through community mapping and regularly updated. Between 10% and 15% of individuals screened were deemed ineligible for the cohort. The primary reason for ineligibility was not being actively engaged in sex work at baseline (e.g., did not work within the last 30 days); other reasons accounted for 5% of those screened as ineligible, and included living outside the Metropolitan Vancouver area or being unable to provide informed consent. Following an open cohort design, participants continued to be actively recruited throughout the life of the cohort through extensive ongoing outreach to street, indoor, and online venues. The annual retention of participants under active follow-up was $>90\%$, and primary reasons for attrition included mortality and migration outside Metropolitan Vancouver. Extensive efforts were made to continue to follow women who had

moved outside Metropolitan Vancouver during the study, including mobile outreach/interview teams and phone interviews, to support the high retention rates.

At baseline and semi-annually, participants completed interviewer-administered questionnaires in English, Cantonese, or Mandarin, alongside pre- and post-test counseling and voluntary HIV, STI, and HCV testing; the interviewers were trained and included both experiential (sex workers) and non-experiential staff. The questionnaire collected detailed information on socio-demographic characteristics, sex work patterns, sexual health, substance use, occupational and lifetime violence, health and social services access, and structural features of occupational and residential environments. Participants completed study visits at one of two storefront offices in Metropolitan Vancouver or at their work/home location. All participants received \$40 CAD at each visit for their time, expertise, and travel.

Voluntary HIV, STI, and HCV testing and pre/post-test counseling was performed by a project nurse. As per provincial guidelines, HIV testing was performed using an ELISA, with reactive tests followed by Western blot and individual RNA nucleic acid amplification test (NAAT) testing where necessary. Urine samples were collected to test for acute STIs including gonorrhoea and chlamydia using NAATs. Blood was drawn for syphilis, herpes simplex virus 2 (HSV-2) antibody, and HCV antibody testing. Onsite treatment was provided by the project nurse for symptomatic STIs, and free STI and Papanicolaou testing was also offered, regardless of study enrolment. Nurses offered referral and active connections to care to HIV- and HCV-seropositive women not receiving care, as well as education and referrals to other needed health and social services.

Data analysis

Analyses were restricted to women who were HCV antibody-negative at baseline and who had attended at least one follow-up visit. Independent variables of interest were identified a priori and included socio-demographic characteristics such as age and indigenous ancestry. Time-updated variables used the last 6 months as a reference point and included HIV and acute STI (defined as a new diagnosis of chlamydia, gonorrhoea, or syphilis), assessed based on serological and urine test results; sexual- and drug-related risks, including condom negotiation and use (e.g., inconsistent condom use with clients) and drug use (e.g., non-injection drug use, injection drug use, non-injection crack use); and interactions with health and social services, assessed by asking whether participants had experienced any barriers to accessing healthcare or harm reduction services. Women previously diagnosed as HCV-seropositive were also asked several questions regarding their access and uptake of HCV care, including whether they had received regular blood tests for HCV, had seen an HCV specialist, had been offered HCV treatment, and had been receiving HCV treatment. Other time-updated variables included structural exposures, including the participant's primary place of soliciting clients (coded as outdoor/public vs. indoor/independent), homelessness, client-perpetrated physical/sexual violence, and experiences related to policing and criminalization, including incarceration, police harassment, or arrest.

Kaplan–Meier analyses

Kaplan–Meier methods were used to estimate cumulative HCV incidence. The date of HCV seroconversion was estimated as the midpoint between the last negative and the first positive antibody test result. Participants who remained persistently HCV-seronegative were right-censored at the time of their most recent available HCV antibody test result. Time-zero for all prospective analyses

was the date of recruitment into the respective cohorts. Incidence rates were estimated for the full sample and stratified by risk factors including recent injection drug use, non-injection crack use, and co-infection with HIV or an STI at baseline.

Cox proportional hazards regression

The unadjusted and adjusted relative hazards of HCV seroconversion were calculated using Cox proportional hazards regression. Time-fixed variables included socio-demographic characteristics such as age, duration of sex work, and indigenous ancestry; all other variables (e.g., drug use, sexual behaviors, structural exposures) were treated as time-updated covariates with occurrences in the prior 6 months, based on semi-annual follow-up data. For the multivariable model, a fixed model was built that adjusted for all variables described above that were statistically associated with HCV seroconversion in unadjusted analyses. Given the established role of injection drug use in HCV transmission, multivariable analyses were adjusted for daily, less than daily, or no injection drug use. A complete case analysis was performed, where cases with missing observations were excluded from the multivariable model. Analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC, USA); the threshold for statistical significance was set at $p < 0.05$. All p -values are two-sided.

Results

HCV burden and participant characteristics

At baseline, 324 of 759 sex workers (42.7%) were HCV-seropositive. The median age of participants was 34 years (interquartile range (IQR) 28–42 years) and one-third (34.7%) were of indigenous ancestry. A significantly higher prevalence of HCV was observed among older and indigenous women, as well as among women living with HIV or with acute STIs (Table 1). Women who used drugs faced a disproportionately higher HCV burden; in comparison to HCV-seronegative women, those who were HCV-seropositive at baseline were significantly more likely to inject drugs daily (42.0% vs. 6.2%) or less than daily (33.3% vs. 6.2%) and to

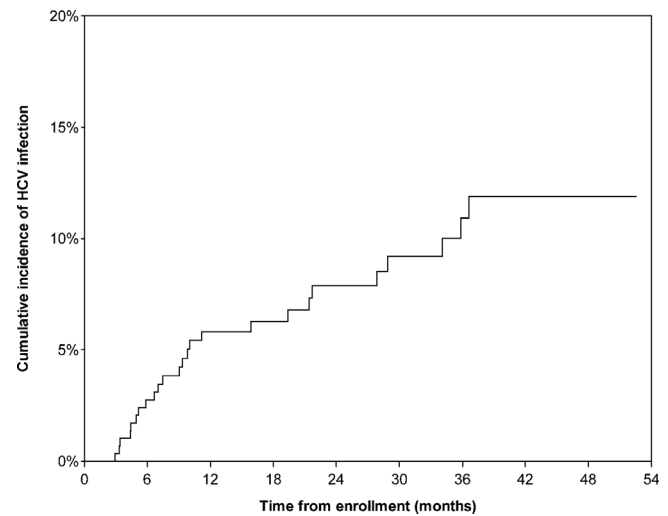


Figure 1. Kaplan–Meier cumulative HCV incidence among HCV-antibody negative women sex workers ($n = 292$) in Metropolitan Vancouver, 2010–2014.

have used non-injection crack (86.1% vs. 39.5%) in the previous 6 months.

HCV incidence density and predictors of time to HCV seroconversion

At baseline, 292 women were HCV-antibody negative and had attended at least one follow-up visit and were thus included in the incidence analyses, contributing 1007 observations to the analysis and over 52.5 months of follow-up.

During the observation period, 25 new HCV seroconversions were identified, yielding an incidence density of 3.84/100 person-years (PY) (95% confidence interval (CI) 2.58–5.71). The Kaplan–Meier cumulative incidence after 52.5 months of follow-up was 11.9% (Figure 1). HCV incidence density was highest among women who used injection drugs, at 23.30/100 PY (95% CI 13.88–39.12)

Table 1

Descriptive statistics by baseline HCV prevalence among women sex workers in Metropolitan Vancouver, 2010–2014 ($N = 759$).

Variable	HCV-seropositive ($n = 324$), n (%)	HCV-seronegative ($n = 435$), n (%)	Total ($N = 759$), n (%)
Age, years (median, IQR)	36 (30–43)	33 (26–41)	34 (28–42)
Canadian-born	299 (92.3%)	234 (53.8%)	533 (70.2%)
Indigenous	160 (49.4%)	103 (23.7%)	263 (34.7%)
HIV-seropositive	76 (23.5%)	7 (1.6%)	83 (10.9%)
STI-seropositive	59 (18.2%)	26 (6.0%)	85 (11.2%)
Duration of sex work, years (median, IQR)	16 (10–23)	4 (1–10)	9 (3–17)
Inconsistent condom use (clients) ^a	73 (22.5%)	66 (15.2%)	139 (18.3%)
Anal sex with clients ^a	62 (19.1%)	40 (9.2%)	102 (13.4%)
Any injection drug use ^a	244 (75.3%)	54 (12.4%)	298 (39.3%)
Injection drug use ^a			
Daily use	136 (42.0%)	27 (6.2%)	163 (21.5%)
Less than daily use	108 (33.3%)	27 (6.2%)	135 (17.8%)
No injection drug use	80 (24.7%)	381 (87.6%)	461 (60.7%)
Any non-injection drug use ^a	302 (93.2%)	211 (48.5%)	513 (67.6%)
Crack use			
Non-injection crack use ^a	279 (86.1%)	172 (39.5%)	451 (59.4%)
Injection crack use ^a	33 (10.2%)	7 (1.6%)	40 (5.3%)
Primary place of solicitation ^a			
Outdoor/public	251 (77.5%)	149 (34.3%)	400 (52.7%)
Indoor/independent	73 (22.5%)	286 (65.7%)	359 (47.3%)

Note: All data refer to n (%) of participants, unless specified otherwise. HCV, hepatitis C virus; IQR, interquartile range; STI, sexually transmitted infection.

^a In the last 6 months.

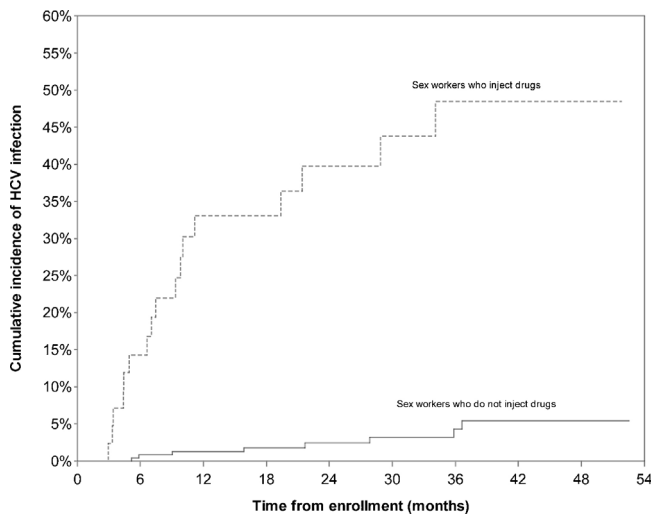


Figure 2. Kaplan–Meier cumulative HCV incidence among HCV-antibody negative women sex workers ($n = 292$) in Metropolitan Vancouver, 2010–2014, stratified by injection drug use.

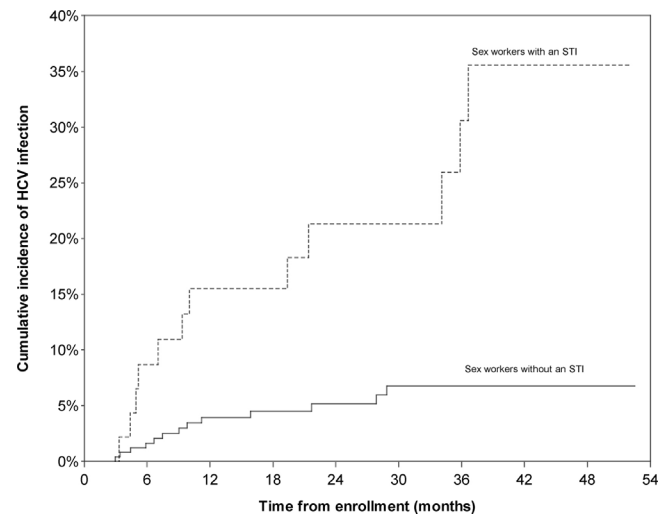


Figure 4. Kaplan–Meier cumulative HCV incidence among HCV-antibody negative women sex workers ($n = 292$) in Metropolitan Vancouver, 2010–2014, stratified by acute sexually transmitted infection (STI).

(Figure 2), and was also significantly higher among women who used non-injection crack, at 6.27/100 PY (95% CI 3.98–9.86) (Figure 3). HCV incidence was also particularly high among women living with HIV (13.27/100 PY, 95% CI 3.27–53.88) or who had an acute STI (5.10/100 PY, 95% CI 1.31–19.83) (Figure 4).

In unadjusted Cox regression models, the relative hazard of HCV seroconversion was higher among women who were younger (hazard ratio (HR) 0.91/year, 95% CI 0.85–0.96), living with HIV (HR 3.71, 95% CI 0.91–15.10), had an acute STI (HR 6.93, 95% CI 2.84–16.92) (Table 2), and used non-injection crack (HR 6.41, 95% CI 2.43–16.90). The hazard of HCV seroconversion was substantially higher among sex workers who solicited clients in outdoor/public spaces (HR 4.34, 95% CI 1.80–10.49), had experienced recent homelessness (HR 4.14, 95% CI 1.91–9.00), and had faced structural risks related to policing and criminalization, including recent incarceration (HR 4.02, 95% CI 1.60–10.09).

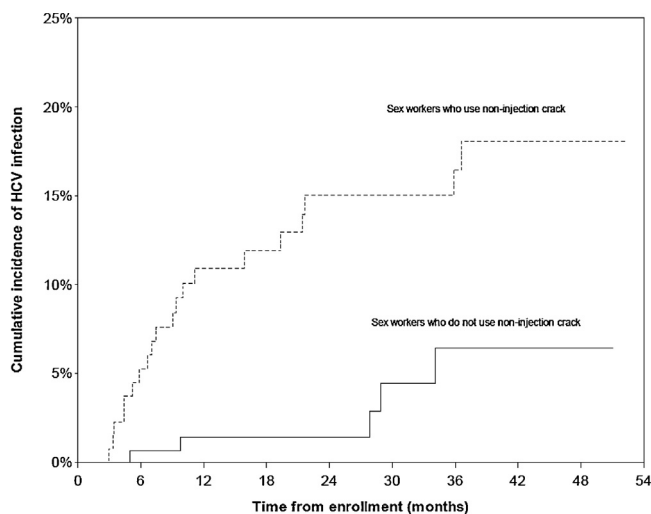


Figure 3. Kaplan–Meier cumulative HCV incidence among HCV-antibody negative women sex workers ($n = 292$) in Metropolitan Vancouver, 2010–2014, stratified by non-injection crack use.

In a multivariable Cox proportional hazards regression model, after adjustment for injection drug use, STI (HR 2.49, 95% CI 1.02–6.06) and non-injection crack use (HR 2.71, 95% CI 1.18–6.25) remained independent predictors of time to HCV seroconversion, and younger age was a marginally significant predictor (HR 0.94, 95% CI 0.86–1.01; $p = 0.10$). In a multivariable Cox proportional hazards regression model, after adjustment for injection drug use, STI infection (HR: 2.49, 95%CI: 1.02–6.06), (HR 2.49, 95% CI 1.02–6.06) and non-injection crack use (HR: 2.71, 95%CI: 1.18–6.25) remained independent predictors of time to HCV seroconversion, : 0.94, 95%CI: 0.86–1.01; and younger age was a marginally significant predictor (HR 0.94, 95% CI 0.86–1.01; $p = 0.10$) (Table 3).

Discussion

In this 4.5-year study, after adjusting for injection drug use, younger age, having an STI, and using non-injection crack were independently associated with time to HCV seroconversion among women sex workers in Metropolitan Vancouver, Canada. HCV

Table 2
Bivariate Cox analysis of time to incident HCV infection among sex workers in Metropolitan Vancouver, 2010–2014 ($n = 292$).

Variable	HR	95% CI
Age, years	0.91	0.85–0.96
Indigenous	2.07	0.95–4.52
HIV-seropositive	3.71	0.91–15.10
STI-seropositive	6.93	2.84–16.92
Duration of sex work, years	1.01	0.98–1.04
Inconsistent condom use (clients) ^a	3.64	1.62–8.21
Anal sex with clients ^a	1.34	0.41–4.38
Non-injection crack use ^a	6.41	2.43–16.90
Primarily solicits clients in outdoor/public spaces ^a	4.34	1.80–10.49
Homelessness ^a	4.14	1.91–9.00
Client physical/sexual violence ^a	2.94	1.17–7.36
Incarceration ^a	4.02	1.60–10.09
Police harassment ^a	2.27	0.98–5.25

HCV, hepatitis C virus; HR, hazard ratio; CI, confidence interval; STI, sexually transmitted infection.

^a Time-updated measures using the last 6 months as a reference.

Table 3

Multivariable Cox analysis of time to incident HCV infection among sex workers in Metropolitan Vancouver, 2010–2014 ($n = 292$)^a.

Variable	Adjusted HR	95% CI
Age, years	0.94	0.86–1.01
STI-seropositive	2.49	1.02–6.06
Non-injection crack use ^b	2.71	1.18–6.25

HCV, hepatitis C virus; HR, hazard ratio; CI, confidence interval; STI, sexually transmitted infection.

^a Results are adjusted for daily, less than daily, or no injection drug use in the last 6 months. Other variables that were considered, but not retained, in the final model included client-perpetrated physical/sexual violence and incarceration in the last 6 months.

^b Time-updated measures using the last 6 months as a reference.

incidence was measured at 3.84/100 PY and was highest among women who used injection drugs (23.30/100 PY) and was also measurably higher among women using non-injection crack (6.27/100 PY), as well as those living with HIV (13.27/100 PY). Although studies with PWID have estimated HCV incidence to be between 20 and 40/100 PY,⁶ declining incidence has been demonstrated among PWID in Vancouver and other settings characterized by the scale-up of effective, community-based harm reduction programs.^{20,21} To the authors' knowledge, this is the first study to examine HCV incidence in a large cohort of sex workers, complementing the few prior studies that have examined HCV prevalence among sex workers elsewhere.^{12,22,23} In comparison to an estimated HCV prevalence of 0.8–2.8% in the general Canadian population,^{24,25} 43% of sex workers were HCV-seropositive. The disproportionate HCV burden and relatively high incidence experienced by sex workers in this context highlight the urgent imperative to scale up tailored and targeted HCV prevention, treatment, and care for marginalized women.

Whereas the sharing of drug paraphernalia and reuse of syringes are the most commonly acknowledged routes of HCV transmission, STIs and non-injection stimulant use also appeared to be important pathways to HCV infection in this study, suggesting the potential for dual sexual and drug-related transmission among sex workers. Alongside drug-related risks, studies have identified HIV and STI co-infections and sex with multiple partners as risk factors for HCV acquisition, particularly within high-income, low-prevalence settings.^{2,26,27} In the Women's Interagency HIV Study, after adjusting for drug use, women living with HIV were almost twice as likely to be HCV-seropositive,²⁸ an association primarily explained by sex with male PWID. Among MSM, Canadian and European studies have found sex worker involvement to be associated with HCV seropositivity; for example, in a Canadian study, HCV-seropositivity was found to be associated with a gonorrhea diagnosis among MSM with no history of injection drug use.⁷

In this study, non-injection crack use represented an important predictor of HCV seroconversion among sex workers; although a small proportion of women also reported using injected crack (5.3%), the small number of events of injection crack use during follow-up prevented its inclusion in the Cox analysis. Prior work has demonstrated the potential for both drug-related and sexual HCV transmission. Shared non-injection drug use paraphernalia (e.g., mouthpieces, straws)²⁹ and the use of inhaled and smoked stimulants (e.g., crack, cocaine) have been associated with an elevated HCV prevalence among substance-using and low-income women,²⁷ women at risk of or living with HIV in the USA,³⁰ and men and women who use drugs.³¹ Additionally, previous work has shown that elevated sexual- and drug-related risks are often experienced within the context of overlapping risks related to sex work and crack use^{9,32}; for example, associations have been

reported between HCV infection and non-injection (i.e., inhaled, smoked) crack use, as well as sex work while using crack.³² In Vancouver, it has previously been shown that stimulant use (e.g., crack, crystal meth) within the context of sex work relates to broader patterns of poorer health outcomes and enhanced structural vulnerabilities,^{18,19} including an enhanced risk of violence, poor housing, police harassment, and reduced health access.¹⁸ Importantly, previous work has suggested that gendered dynamics may be linked to enhanced HCV-related vulnerability among stimulant-using women, for whom sexual- and drug-related risks are frequently experienced within the context of intimate and paid relationships with substance-using male partners.^{9,19,28,32} Although this body of evidence supports the notion that the associations documented between STIs and non-injection crack use in the present study may be attributable to overlapping sexual and non-injection-related drug transmission of HCV, it is also possible that these variables to some extent may represent markers of a higher-risk population of sex workers, rather than actual transmission pathways. Future studies with sex workers and other populations that may be exposed to dual sexual and drug-related risks are recommended to further explore these transmission pathways across diverse settings.

Younger sex workers in this cohort also faced a trend towards higher HCV incidence, pointing to gaps in harm reduction and HCV prevention efforts for marginalized young women. In high-income contexts such as the USA and Australia, HCV transmission is disproportionately concentrated among young adults,² and North American studies indicate that street-involved youth who use drugs are highly vulnerable to HCV.^{33,34} Importantly, the present findings build on a prior study among drug-using youth in Vancouver, which found that sex work involvement was associated with HCV seroconversion for youth.¹⁵ These findings can be contextualized by previous research involving marginalized populations, including sex workers and people who use drugs, which showed that youth often face a greater risk of blood-borne infections and STIs due to the enhanced challenges faced negotiating condom use and drug-related harms (frequently with older partners), particularly within the context of recent sex work or drug use initiation.^{17,33}

Public health implications

In this study, while HCV incidence was highest among women who inject drugs, sex workers with acute STIs and those who used non-injection crack also faced a substantially increased risk of HCV acquisition, highlighting the need to integrate HCV services with sexual health and HIV/STI and substance use prevention and treatment programs in this setting. The concerning trend of higher HCV incidence among younger women underscores the need for youth and sex worker-friendly HCV programming. These recommendations are supported by the recently adopted global health sector strategies for HIV, viral hepatitis, and STIs (2016–2021), which include greater integration across HIV, STI, and viral hepatitis prevention, treatment, and care, and a purposeful focus on key populations, including sex workers. The pervasive barriers sex workers face to HIV, sexual health, and harm reduction services have been linked primarily to the enforcement of criminalized legal approaches to sex work. For example, displacement due to policing and the resulting lack of safe working and living environments for sex workers often undermine access to HIV, health, and harm reduction services.¹⁸ As such, structural interventions, including the decriminalization of sex work, remain critical to ensuring access to HIV, HCV, and harm reduction programs.

The severe gaps in HCV testing and treatment faced by sex workers in Vancouver have recently been demonstrated, with

fewer than half of HCV-positive women being connected to care and almost none having received treatment.³⁵ Despite the high HCV prevalence and incidence among sex workers, most HCV-related services target PWID, with a lack of sex worker-tailored or women-centered models of care. While HCV treatment uptake has been historically low for substance-using populations, new, highly effective and tolerable HCV treatments represent an opportunity to scale up voluntary and respectful treatment access. Importantly, recent studies have demonstrated that marginalized and substance-using populations can achieve rates of virological response comparable to the general population,⁴ with modeling also suggesting that expanding harm reduction and HCV treatment access to persons at increased risk for transmission has the potential to reduce HCV incidence and prevalence in a cost-effective manner.⁴

Conclusions

In this study, while HCV incidence was highest among sex workers who injected drugs and women living with HIV, STIs and non-injection stimulant crack use appear to be pathways to HCV infection, suggesting potential dual sexual and drug-related transmission of HCV. Altogether, the findings from this study highlight the urgent need to integrate HCV services with sexual health and HIV/STI addiction and harm reduction programs for marginalized women. In light of the very high HCV prevalence and incidence rates among sex workers and the recent availability of highly effective and tolerable HCV treatment regimens, targeted, community-based efforts to offer voluntary HCV prevention (including prevention of re-infection), testing, treatment, and care to sex workers should be a critical public health and human rights priority.

Conflict of interest

No conflict of interest to declare.

Acknowledgements

We thank all of those who contributed their time and expertise to this project, particularly the participants, AESHA community advisory board members, and partner agencies. We wish to acknowledge Chrissy Taylor, Jill Chettiar, Jennifer Morris, Tina Ok, Avery Alder, Emily Groundwater, Jane Li, Sylvia Machat, Lauren Martin McCraw, Minshu Mo, Brittany Udall, Rachel Nicoletti, Emily Sarah Leake, Ray Croy, Natalie Blair, Anita Dhanoa, Emily Sollows, Nelly Gomez, Bridget Simpson, Jenn McDermid, Alka Murphy, Paul Nguyen, Sabina Dobrer, Kathleen Deering, Krista Butler, Layla Cameron, and Peter Vann for their research and administrative support. This work was supported by the US National Institutes of Health (R01DA028648), the Canadian Institutes of Health Research (HHP-98835), Canadian Institutes of Health Research/Public Health Agency of Canada (HEB-330155), and MacAIDS. KS is partially supported by a Canada Research Chair in Global Sexual Health and HIV/AIDS and Michael Smith Foundation for Health Research. SG is partially supported by a Canadian Institutes of Health Research New Investigator Award and the US National Institutes of Health. MES is supported by a Michael Smith Foundation for Health Research post-doctoral fellowship award and a Canada Addiction Medicine Research Fellowship (US National Institute on Drug Abuse, R25-DA037756). JSGM has received limited unrestricted funding, paid to his institution, from AbbVie, Bristol-Myers Squibb, Gilead Sciences, Janssen, Merck, and ViiV Healthcare. JSGM is supported with grants paid to his institution by

the British Columbia Ministry of Health and by the US National Institutes of Health (R01DA036307).

References

1. World Health Organization. *Hepatitis C Fact sheet*. Geneva: WHO; 2015.
2. Alter MJ. Epidemiology of hepatitis C virus infection. *World J Gastroenterol* 2007;**13**:2436.
3. World Health Assembly. *Draft global health sector strategies*. Geneva: World Health Organization; 2016.
4. Grebely J, Robaey G, Bruggmann P, Aghemo A, Backmund M, Bruneau J, et al. Recommendations for the management of hepatitis C virus infection among people who inject drugs. *Int J Drug Policy* 2015;**26**:1028–38.
5. Martin NK, Vickerman P, Dore GJ, Hickman M. The hepatitis C virus epidemics in key populations (including people who inject drugs, prisoners and MSM): the use of direct-acting antivirals as treatment for prevention. *Curr Opin HIV AIDS* 2015;**10**:374–80.
6. Hagan H, Pouget ER, Des Jarlais DC. A systematic review and meta-analysis of interventions to prevent hepatitis C virus infection in people who inject drugs. *J Infect Dis* 2011;**204**:74–83.
7. Wong J, Moore D, Kanters S, Buxton J, Robert W, Gustafson R, et al. Seroprevalence of hepatitis C and correlates of seropositivity among men who have sex with men in Vancouver, Canada: a cross-sectional survey. *Sex Transm Infect* 2015;**91**:430–3.
8. Shannon K, Strathdee SA, Goldenberg SM, Duff P, Mwangi P, Rusakova M, et al. Global epidemiology of HIV among female sex workers: influence of structural determinants. *Lancet* 2015;**385**:55–71.
9. Duff P, Tyndall M, Buxton J, Zhang R, Kerr T, Shannon K. Sex-for-crack exchanges: associations with risky sexual and drug use niches in an urban Canadian city. *Harm Reduct J* 2013;**10**:1.
10. Goldenberg SM, Montaner J, Duff P, Nguyen P, Dobrer S, Guillemi S, Shannon K. Structural barriers to antiretroviral therapy among HIV seropositive female sex workers: findings of a longitudinal study in Vancouver, Canada. *AIDS Behav* 2015;**20**:977–86.
11. Socias ME, Shannon K, Horton M, Nguyen P, Lyons T, Martin R, Manoe M, Deering KN. Recent incarceration correlated with reduced access to HIV prevention in a longitudinal study of sex workers who inject drugs in a Canadian urban centre. *8th IAS Conference on HIV Pathogenesis, Treatment and Prevention*. Vancouver, Canada.
12. Uusküla A, Fischer K, Raudne R, Kilgi H, Roman K, Salminen M, et al. A study on HIV and hepatitis C virus among commercial sex workers in Tallinn. *Sex Transm Infect* 2008;**84**:189–91.
13. Bautista CT, Pando MA, Reynaga E, Marone R, Saterén W, Montano S, et al. Sexual practices, drug use behaviors, and prevalence of HIV, syphilis, hepatitis B and C, and HTLV-1/2 in immigrant and non-immigrant female sex workers in Argentina. *J Immigr Minor Health* 2009;**11**:99–104.
14. Kweon SS, Shin MH, Song HJ, Jeon DY, Choi JS. Seroprevalence and risk factors for hepatitis C virus infection among female commercial sex workers in South Korea who are not intravenous drug users. *Am J Trop Med Hyg* 2006;**74**:1117–21.
15. Shannon K, Kerr T, Marshall B, Li K, Zhang R, Strathdee SA, et al. Survival sex work involvement as a primary risk factor for hepatitis C virus acquisition in drug-using youths in a Canadian setting. *Arch Pediatr Adolesc Med* 2010;**164**:61–5.
16. Taylor A, Hutchinson SJ, Gilchrist G, Cameron S, Carr S, Goldberg DJ. Prevalence and determinants of hepatitis C virus infection among female drug injecting sex workers in Glasgow. *Harm Reduct J* 2008;**5**:1.
17. Goldenberg SM, Chettiar J, Simo A, Silverman JG, Strathdee SA, Montaner J, et al. Early sex work initiation independently elevates odds of HIV infection and police arrest among adult sex workers in a Canadian setting. *J Acquir Immune Defic Syndr* 2014;**65**:122–8.
18. Shannon K, Strathdee S, Shoveller J, Zhang R, Montaner J, Tyndall M. Crystal methamphetamine use among female street-based sex workers: moving beyond individual-focused interventions. *Drug Alcohol Depend* 2011;**113**:76–81.
19. Shannon K, Bright V, Gibson K, Tyndall M. Sexual and drug-related vulnerabilities for HIV infection among women engaged in survival sex work in Vancouver, Canada. *Can J Public Health* 2007;**98**:465–9.
20. Grebely J, Lima VD, Marshall BD, Milloy MJ, DeBeck K, Montaner J, et al. Declining incidence of hepatitis C virus infection among people who inject drugs in a Canadian setting, 1996–2012. *PLoS One* 2014;**9**:e97726.
21. Iversen J, Wand H, Topp L, Kaldor J, Maher L. Reduction in HCV incidence among injection drug users attending needle and syringe programs in Australia: a linkage study. *Am J Public Health* 2013;**103**:1436–44.
22. Inciardi JA, Surratt HL, Kurtz SP. HIV, HBV, and HCV infections among drug-involved, inner-city, street sex workers in Miami, Florida. *AIDS Behav* 2006;**10**:139–47.
23. Johnston LG, Corceal S. Unexpectedly high injection drug use, HIV and hepatitis C prevalence among female sex workers in the Republic of Mauritius. *AIDS Behav* 2013;**17**:574–84.
24. Shah HA, Heathcote J, Feld JJ. A Canadian screening program for hepatitis C: is now the time? *Can Med Assoc J* 2013;**185**:1325–8.
25. Uhanova J, Tate RB, Tataryn DJ, Minuk GY. A population-based study of the epidemiology of hepatitis C in a North American population. *J Hepatol* 2012;**57**:736–42.
26. Tohme RA, Holmberg SD. Is sexual contact a major mode of hepatitis C virus transmission? *Hepatology* 2010;**52**:1497–505.

27. Page-Shafer KA, Cahoon-Young B, Klausner JD, Morrow S, Molitor F, Ruiz J, et al. Hepatitis C virus infection in young, low-income women: the role of sexually transmitted infection as a potential cofactor for HCV infection. *Am J Public Health* 2002;**92**:670–6.
28. Frederick T, Burian P, Terrault N, Cohen M, Augenraun M, Young M, et al. Factors associated with prevalent hepatitis C infection among HIV-infected women with no reported history of injection drug use: the Women's Interagency HIV Study (WIHS). *AIDS Patient Care STDS* 2009;**23**:915–23.
29. Tortu S, McMahon JM, Pouget ER, Hamid R. Sharing of noninjection drug-use implements as a risk factor for hepatitis C. *Substance Use Misuse* 2004;**39**:211–24.
30. Operskalski EA, Mack WJ, Strickler HD, French AL, Augenraun M, Tien PC, et al. Factors associated with hepatitis C viremia in a large cohort of HIV-infected and -uninfected women. *J Clin Virol* 2008;**41**:255–63.
31. Fischer B, Rehm J, Patra J, Kalousek K, Haydon E, Tyndall M, et al. Crack across Canada: comparing crack users and crack non-users in a Canadian multi-city cohort of illicit opioid users. *Addiction* 2006;**101**:1760–70.
32. Shannon K, Rusch M, Morgan R, Oleson M, Kerr T, Tyndall MW. HIV and HCV prevalence and gender-specific risk profiles of crack cocaine smokers and dual users of injection drugs. *Substance Use Misuse* 2008;**43**:521–34.
33. Miller CL, Kerr T, Fischer B, Zhang R, Wood E. Methamphetamine injection independently predicts hepatitis C infection among street-involved youth in a Canadian setting. *J Adolesc Health* 2009;**44**:302–4.
34. Page K, Hahn JA, Evans J, Shiboski S, Lum P, Delwart E, et al. Acute hepatitis C virus infection in young adult injection drug users: a prospective study of incident infection, resolution, and reinfection. *J Infect Dis* 2009;**200**:1216–26.
35. Socías ME, Shannon K, Montaner JS, Guillemi S, Dobrer S, Nguyen P, et al. Gaps in the hepatitis C continuum of care among sex workers in Vancouver, British Columbia: implications for voluntary hepatitis C virus testing, treatment and care. *Can J Gastroenterol Hepatol* 2015;**29**:411–6.