



Syringe sharing among people who inject drugs in London, Canada

Ayden I. Scheim^{1,2} · Geoff Bardwell^{3,4} · Beth Rachlis^{5,6} · Sanjana Mitra^{3,7} · Thomas Kerr^{3,4}

Received: 11 September 2017 / Accepted: 20 January 2018 / Published online: 6 June 2018
© The Canadian Public Health Association 2018

Abstract

Objectives London, Ontario, is facing an outbreak of HIV among people who inject drugs (PWID), as well as persistently high levels of hepatitis C virus (HCV). Syringe sharing is the primary driver of HIV and HCV transmission risks among PWID, however, little is known about factors contributing to syringe sharing in this setting. Therefore, we sought to characterize syringe sharing and its correlates among London PWID.

Methods Between March and April, 2016, PWID participated in a survey administered by peer research associates as part of the Ontario Integrated Supervised Injection Services Feasibility Study. Bivariable and multivariable logistic regression models examined associations with syringe sharing (borrowing or lending previously used syringes) over the previous 6 months. A sub-analysis described patterns of borrowing and lending by self-reported HIV and HCV statuses.

Results Of 198 PWID, 44 (22%) reported syringe sharing in the past 6 months. In the multivariable analysis, selling drugs (adjusted odds ratio; AOR = 1.92, 95% CI = 1.20–3.08), daily crystal methamphetamine injection (AOR = 1.66, 95% CI = 1.07–2.59), and identifying as HIV-positive (AOR = 3.11, 95% CI = 1.61–6.01) were independently associated with increased syringe sharing. While not independently associated with syringe sharing, problems accessing syringes were common (13–50%). Self-reported HIV-positive respondents were more likely to report syringe borrowing ($p < 0.001$), but not lending ($p = 0.26$).

Conclusion We observed a high rate of syringe sharing among London PWID, with sharing being associated with high-intensity injection of crystal methamphetamine, as well as with involvement in drug sales. Considering the current HIV outbreak in London, multi-level prevention efforts are urgently needed.

Résumé

Objectifs La ville de London (Ontario) est confrontée à une éclosion de VIH chez les personnes qui utilisent des drogues par injection (UDI), ainsi qu'à des niveaux durablement élevés de virus de l'hépatite C (VHC). Le partage de seringues est le principal vecteur des risques de transmission du VIH et du VHC chez les UDI, mais on en sait peu sur les facteurs qui contribuent au partage de seringues dans ce milieu. C'est pourquoi nous avons voulu caractériser le partage de seringues et ses corrélats chez les UDI de London.

Méthode Entre mars et avril 2016, des UDI ont participé à un sondage administré par des pairs associés de recherche dans le cadre d'une étude de faisabilité d'Ontario Integrated Supervised Injection Services (OISIS). Des modèles de régression logistique bivariés et multivariés ont permis d'examiner les associations avec le partage de seringues (l'emprunt ou le prêt de seringues déjà utilisées) au cours des six mois antérieurs. Une sous-analyse a porté sur les schémas d'emprunt et de prêt selon l'état sérologique autodéclaré relativement au VIH et au VHC.

✉ Thomas Kerr
uhri-tk@cfenet.ubc.ca

¹ Department of Epidemiology and Biostatistics, Schulich School of Medicine and Dentistry, Western University, London, ON N6A 5C1, Canada

² Division of Infectious Diseases and Global Public Health, University of California San Diego School of Medicine, 9500 Gilman Drive, La Jolla, CA 92093, USA

³ British Columbia Centre on Substance Use, 400-1045 Howe St, Vancouver, BC V6Z 2A9, Canada

⁴ Department of Medicine, University of British Columbia, St. Paul's Hospital, 608-1081 Burrard Street, Vancouver, BC V6Z 1Y6, Canada

⁵ Ontario HIV Treatment Network, 1300 Yonge Street, Suite 600, Toronto, ON M4T 1X3, Canada

⁶ Division of Clinical Public Health, Dalla Lana School of Public Health, University of Toronto, 155 College Street West, 6th floor, Toronto, ON M5T 3M7, Canada

⁷ Interdisciplinary Studies, University of British Columbia, 270-2357 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada

Résultats Sur les 198 UDI, 44 (22%) ont dit avoir partagé des seringues au cours des 6 mois antérieurs. Dans l'analyse multivariée, la vente de drogue (rapport de cotes ajusté; RCA = 1,92, IC de 95% = 1,20–3,08), l'injection quotidienne de méthamphétamine (RCA = 1,66, IC de 95% = 1,07–2,59) et la séropositivité VIH autodéclarée (RCA = 3,11, IC de 95% = 1,61–6,01) étaient indépendamment associées au partage de seringues accru. Bien qu'ils ne soient pas indépendamment associés au partage de seringues, les problèmes d'accès aux seringues étaient courants (13–50%). Les répondants s'étant déclarés séropositifs pour le VIH étaient plus susceptibles de dire avoir emprunté des seringues ($p < 0,001$), mais pas d'en avoir prêté ($p = 0,26$).

Conclusion Nous avons observé un taux élevé de partage de seringues chez les UDI de London, ce partage étant associé à l'injection intensive de méthamphétamine et à la participation à la vente de drogue. Étant donné l'éclosion de VIH qui sévit à London actuellement, des efforts de prévention à plusieurs niveaux sont nécessaires de toute urgence.

Keywords Substance abuse, intravenous · Syringe sharing · HIV · Harm reduction

Mots-clés Toxicomanie intraveineuse · Partage de seringue · VIH · Réduction des dommages

Introduction

Epidemics of both human immunodeficiency virus (HIV) and hepatitis C (HCV) persist among people who inject illicit drugs (PWID) globally, and are expanding in some settings, primarily as a result of the sharing of injection equipment (Mathers et al. 2008). In the Canadian context, while HIV incidence among PWID has declined due to scale-up of harm reduction interventions (needle distribution and opioid agonist therapy) and access to antiretroviral therapy (Nosyk et al. 2017), it remains a concern in some settings.

In Ontario, approximately 12% of new HIV diagnoses between 2005 and 2014 were attributable to injection drug use, a proportion that has remained fairly stable over the past decade (Gilbert 2015). Thus, public health officials in London and Middlesex County, Ontario (census division population 456,000), were alarmed to record the largest number of new HIV diagnoses ever in 2016 (58 cases), of which about 70% were among PWID (Middlesex-London Health Unit 2017). The Middlesex-London Health Unit also reported increasing incidence of HCV, invasive group A streptococcal disease (iGAS), and endocarditis among PWID (Middlesex-London Health Unit 2017).

In many ways, London is an “average” Canadian city. Based on demographic and socio-economic characteristics, Statistics Canada classifies the Middlesex-London health region as part of a peer group of similar municipalities that included 33.9% of the Canadian population in 2006 (Statistics Canada 2013). Relative to other cities, however, London has a high level of poverty. The prevalence of low income in the London census metropolitan area (CMA) increased by 3.7% from 2005 to 2015, and was third-highest among Canadian CMAs in 2015 (Statistics Canada 2017). As in many cities, homelessness and drug use are particularly concentrated in London's core, where most services for PWID are located.

Elevated infectious disease risks for PWID in London first became evident in a 2012 Public Health Agency of Canada study that found higher HCV seropositivity among London participants (79.1%) than the national average (68.0%), accompanied by more reported syringe sharing (Middlesex-London Health Unit 2012). Further, London has been facing challenges related to both prescription opioid and stimulant use, including elevated rates of opioid-related deaths (Middlesex-London Health Unit 2014), growing use of injected crystal methamphetamine (Richmond 2016), and high levels of public injecting (Schein et al. 2017).

London has a longstanding high-volume needle and syringe program (NSP). In 2016, it distributed an estimated three million needles to a municipal population of 384,000 (Richmond 2017). However, availability of NSPs alone is insufficient to eliminate syringe sharing, which has been associated with trouble finding sterile equipment when needed (Shaw et al. 2007; Lloyd-Smith et al. 2009), inconsistent NSP utilization (Jenness et al. 2011), and policies that emphasize syringe exchange over distribution (Kerr et al. 2010). Socio-demographic characteristics, social-structural exposures, and drug use behaviours also impact syringe sharing. For instance, younger age (Kerr et al. 2010; Bozinoff et al. 2017), homelessness (Bozinoff et al. 2017), recent incarceration (Wood et al. 2005), injecting with sex partners or family members (Shaw et al. 2007), and daily cocaine injection (Lloyd-Smith et al. 2009; Wood et al. 2002) have predicted syringe sharing in other Canadian cities.

To our knowledge, no research to date has examined factors associated with syringe sharing among PWID in London, nor in other mid-sized Canadian cities. The emergence of an HIV outbreak in London makes evident that syringe sharing is a significant local public health threat. Inadequate access to harm reduction services, as well as social-structural factors and drug use patterns, may be contributing to this HIV risk behaviour. Therefore, we sought to characterize syringe sharing and its correlates among PWID in London.

Methods

Setting and design

Data were obtained from the Ontario Integrated Supervised Injection Services Feasibility Study, a cross-sectional survey of people who inject drugs in London and Thunder Bay, Ontario (Kerr et al. 2017). The current study focuses on London data only.

Recruitment

Survey data were collected between March and April 2016 by three peer research associates. Eligible participants were aged 18 or above and reported injecting drugs within the previous 6 months. Based on consultation with expert advisors including local health care providers and peer research associates, a targeted recruitment strategy was developed. Potential participants were recruited through outreach by peer research associates (on the street and in venues people who inject drugs are known to frequent), recruitment flyers posted in local health and social service agencies, and word-of-mouth (including peer-to-peer distribution of wallet-sized cards). Survey interviews took place at three community agencies across two neighbourhoods in London's core (including one organization that serves women only). Participants provided written informed consent and were provided a \$25 honorarium. Ethics approval was obtained from research ethics boards at the University of Toronto and the University of British Columbia.

Data collection

The questionnaire was adapted from previous studies of injection drug use and supervised injection feasibility (Kerr et al. 2003), programmed on electronic tablets, and pre-tested for clarity and functionality. Survey questions pertained to socio-demographic characteristics, drug use behaviours, health conditions and health care utilization, and overdose experiences, as well as willingness to use and design preferences for supervised injection services. The questionnaire was administered in English by a peer research associate and took approximately 45 min to complete.

Measures

A copy of the study questionnaire is available online as supplementary material to a previous publication (Schein et al. 2017). Participants were asked, “how often have you borrowed syringes that had already been used by someone else to inject?” and “how often have you loaned syringes that had already been used by you or were being used by someone else to inject?” in the previous 6 months. Consistent with

previous research, syringe sharing was defined as reporting any borrowing and/or lending of used syringes in the previous 6 months (Kerr et al. 2005).

Socio-demographic characteristics and socio-structural exposures included age (in years); gender (male vs. female); ethnicity (white vs. Indigenous/person of colour); sexual minority identity (lesbian, gay, or bisexual vs. heterosexual); homelessness or unstable housing; incarceration; drug selling (reporting “selling drugs” as a source of income); and sex work (including exchanging sex for goods) over the previous 6 months (all yes vs. no unless otherwise indicated). One transgender respondent was classified as female based on self-reported gender identity. Participants had the option to specify a non-binary gender identity but none did so.

Drug use behaviours in the past 6 months included frequent opioid, crystal methamphetamine, or methylphenidate (Ritalin/Biphentin) injection (all daily vs. less often) to reflect the dominant classes of drugs used by the sample. Other drug use characteristics were recent public injecting, injecting in a place where the respondent bought drugs and/or paid to use drugs, injecting with a sexual partner, and needing help injecting (all yes vs. no, over the past 6 months).

Harm reduction service access measures included using an NSP, not knowing where to get clean needles when needed, and having trouble getting enough clean needles from an NSP (all yes vs. no, over the past 6 months).

Finally, HIV and hepatitis C statuses were self-reported based on responses to the question, “What was the result of your last HIV [Hepatitis C] blood test?” and dichotomized as self-reported positive vs. negative or unknown.

Statistical analyses

All analyses were conducted in SAS 9.4 (SAS Institute Inc 2013). Descriptive statistics for socio-demographic characteristics, drug use behaviours, and access to harm reduction services were stratified by recent syringe sharing, and bivariable logistic regression models were used to evaluate associations. To adjust for potential confounding, variables associated with syringe sharing at $p < 0.10$ in bivariate analyses were entered in a multivariable logistic regression model. Missing data were few overall (i.e., less than 3%). However, due to a technical problem, one variable (not knowing where to get needles when needed) was missing data for 1 week of administration ($n = 30$, 15%). Therefore, regression models were fit using multiple imputation via fully conditional specification with 15 imputations (van Buuren 2007), employing all variables in the analysis. The outcome was not imputed.

A sub-analysis was conducted to describe patterns of syringe borrowing and lending stratified by self-reported HIV

and HCV statuses. Frequencies of syringe borrowing and lending were stratified by HIV and HCV statuses, excluding participants who indicated unknown status or declined to answer the question ($n = 15$ for HIV and 13 for HCV). Pearson's χ^2 -test and Fisher's exact test were used to identify significant differences in sharing patterns.

Results

Of 199 participants, 198 (99.5%) provided data pertaining to syringe sharing and are included in this analysis, including 75 women (37.9%). The sample was predominantly white ($n = 146$; 73.7%) and had a median age of 39 (IQR = 33 to 50). Characteristics of the study sample stratified by recent syringe sharing, alongside bivariable odds ratios (OR), are presented in Table 1. Twenty-two percent ($n = 44$) reported syringe sharing in the past 6 months.

Almost all participants (95%, $n = 184$) reported accessing an NSP in the previous 6 months. However, over the same timeframe, 12.8% ($n = 25$) reported trouble getting enough needles or syringes from an NSP. Of 168 participants with complete data, 64 (50%) reported at some point not knowing where to get a clean syringe when they had drugs and wanted to inject. These factors were not significantly associated with syringe sharing in bivariable analyses.

Rather, socio-demographic factors (younger age), social-structural exposures (homelessness or unstable housing, selling drugs), drug use behaviours (number of daily injections, daily crystal methamphetamine injection, public injecting, injecting in a place where the respondent buys drugs or pays to use), and self-reported HIV-positive status were positively associated with syringe sharing in unadjusted analyses (Table 1).

Variables associated with syringe sharing at $p < 0.10$ in bivariable analyses were entered into a multivariable model (see Table 2). Selling drugs (adjusted odds ratio; AOR = 1.92, 95% CI = 1.20–3.08), daily crystal methamphetamine injection (AOR = 1.66, 95% CI = 1.07–2.59), and identifying as HIV-positive (AOR = 3.11, 95% CI = 1.61–6.01) were independently associated with increased syringe sharing (all $p < 0.01$). In the sub-analysis (Table 3), self-reported HIV-positive respondents were more likely to report syringe borrowing ($p < 0.001$), but not lending ($p = 0.26$). A similar pattern was observed for individuals who identified as HCV-positive ($p = 0.02$ vs. 0.13).

Discussion

In the context of an HIV outbreak among London PWID, almost one quarter of this sample reported syringe sharing in the previous 6 months. This appears high in comparison to other Canadian PWID samples. The same proportion (22%) of

PWID in an Ottawa study reported syringe sharing over the past year (Shaw et al. 2015), while 11% in Vancouver reported past-six-month syringe sharing in 2014 (Lee et al. 2015). In our study, syringe sharing was associated with high-intensity injection of crystal methamphetamine and involvement in drug sales. Self-reported HIV-positive status was also associated with sharing; however, a sub-analysis revealed that known HIV and HCV-positive individuals reported statistically significantly greater levels of syringe borrowing, but not lending. Although approximately one quarter (4/17) of HIV-positive respondents did indicate distributive syringe sharing, individuals with undiagnosed HIV infection may also be contributing to onwards transmission risks.

Syringe sharing was not independently associated with access to harm reduction programs, but descriptive results indicate suboptimal coverage of needle distribution. Half of participants did not know where to find a clean needle when they needed one to inject, and 12.8% indicated trouble getting enough needles from an NSP. This is somewhat surprising considering the extraordinary volume of needle distribution in London. In 2015, London NSPs distributed an estimated 2.5 million needles (Campanella 2015), in comparison to 1.9 million in nearby Toronto (Medical Officer of Health 2016), a city with a population over seven times as large. While this volume is impressive, shifting drug use patterns may be impacting the coverage and effectiveness of local NSPs. Although prescription opioids have been the primary drugs illicitly injected in London, a recent increase in crystal methamphetamine injection has been observed (Richmond 2016). Indeed, results from our study indicate that while prescription opioids—principally hydromorphone—remain the drugs most commonly injected daily, crystal methamphetamine was the most commonly injected drug in the past 6 months overall, with 83% reporting any use (Kerr et al. 2017).

Stimulant injection is associated with a higher number of daily injections due to a shorter half-life as compared to opioids (Tyndall et al. 2003). In Vancouver, Canada, NSP programs developed in response to opioid use have proved insufficient to address the needs of stimulant users, and stimulant-related HIV outbreaks have developed (Tyndall et al. 2003). That daily crystal methamphetamine injection was associated with syringe sharing in this study suggests a similar phenomenon may exist in London.

Research undertaken in the wake of Vancouver's HIV epidemic demonstrated that improvements in NSP delivery resulted in substantial declines in syringe sharing and HIV incidence (Kerr et al. 2010). These improvements included separating distribution and recovery functions, increasing the number of NSP outlets, removing one-for-one exchange rules and limits on the number of syringes distributed, as well as increasing the involvement of peers and outreach workers in the distribution of syringes. Some of these best practices are already in place in London's NSP (e.g., no one-to-one exchange rule or limits),

Table 1 Characteristics of SIS feasibility study participants in London, Canada, stratified by recent syringe sharing and bivariable associations ($n = 198$)

Recent syringe sharing*				
Characteristic	Yes ($n = 44$) n (%)	No ($n = 154$) n (%)	Odds ratio (95% CI)	p value
Median age (IQR)	40 (35–50)	33 (28–50)		
1 year increase			0.95 (0.92–0.98)	< 0.01
Gender				
Female	16 (36.4)	59 (38.3)	0.92 (0.46–1.84)	0.814
Male	28 (63.6)	95 (61.7)		
Ethnicity				
White	30 (69.8)	116 (76.3)	0.84 (0.58–1.23)	0.370
Indigenous/of colour	13 (30.2)	36 (23.7)		
Sexual minority [‡]				
Yes	10 (22.7)	24 (15.6)	1.59 (0.70–3.65)	0.270
No	34 (77.3)	130 (84.4)		
Homeless/unstably housed [†]				
Yes	34 (77.3)	79 (51.3)	3.23 (1.49–6.99)	< 0.001
No	10 (22.7)	75 (48.7)		
Recent incarceration [†]				
Yes	9 (20.5)	15 (9.7)	2.38 (0.96–5.89)	0.060
No	35 (79.6)	139 (90.3)		
Sold drugs [†]				
Yes	21 (47.7)	42 (27.3)	2.43 (1.22–4.85)	0.011
No	23 (52.3)	112 (72.7)		
Sex work [†]				
Yes	13 (29.6)	25 (16.2)	2.16 (1.00–4.70)	0.051
No	31 (70.5)	129 (83.8)		
Number of daily injections [†]	4 (2–6)	6 (4–11)		
Per one-unit increase	–	–	1.05 (1.00–1.10)	0.034
Daily opioid injection				
Yes	28 (63.6)	78 (51.0)	1.66 (0.92–1.83)	0.145
No	16 (36.4)	75 (49.0)		
Daily crystal methamphetamine injection				
Yes	26 (59.1)	43 (27.9)	3.73 (1.86–7.48)	< 0.001
No	18 (40.9)	111 (72.1)		
Daily methylphenidate injection				
Yes	8 (18.2)	41 (26.8)	0.61 (0.26–1.43)	0.256
No	36 (81.8)	112 (73.2)		
Injected in public [†]				
Yes	38 (86.4)	102 (66.2)	2.96 (1.17–7.46)	0.022
No	6 (13.6)	49 (31.8)		
Injected in a place where you buy drugs or pay to use [†]				
Yes	22 (50.0)	45 (29.2)	2.42 (1.22–4.81)	0.011
No	22 (50.0)	109 (70.8)		
Injected with a sex partner [†]				
Yes	24 (54.6)	104 (67.5)	0.58 (0.29–1.14)	0.114
No	20 (45.5)	50 (32.5)		
Needed help injecting [†]				
Yes	16 (36.4)	46 (29.9)	1.34 (0.66–2.71)	0.414
No	28 (63.6)	108 (70.1)		

Table 1 (continued)

Recent syringe sharing*				
Characteristic	Yes (<i>n</i> = 44) <i>n</i> (%)	No (<i>n</i> = 154) <i>n</i> (%)	Odds ratio (95% CI)	<i>p</i> value
Used NEP ^{†§}				
Yes	41 (93.2)	143 (96.0)	0.75 (0.37–1.54)	0.435
No	3 (6.8)	6 (4.0)		
Didn't know where to get a clean needle when needed [†]				
Yes	26 (63.4)	58 (45.7)	1.40 (0.98–2.00)	0.064
No	15 (36.6)	69 (54.3)		
Trouble getting enough needles from NEP ^{†§}				
Yes	7 (16.3)	18 (11.8)	1.24 (0.77–1.99)	0.382
No	36 (83.7)	134 (88.2)		
Self-reported HIV-positive				
Yes	10 (22.7)	8 (5.2)	5.37 (1.97–14.62)	<i>0.001</i>
No	34 (77.3)	146 (94.8)		
Self-reported hepatitis C positive				
Yes	29 (65.9)	76 (49.4)	1.98 (0.99–3.99)	0.055
No	15 (34.1)	78 (50.7)		

Results statistically significant at $p < 0.05$ are indicated in italics

*Any syringe borrowing or lending over the previous 6 months

[†] Over the previous 6 months

[‡] Lesbian, gay, or bisexual

[§] NEP = needle exchange program

and expansion of NSP hours and venues (e.g., including to pharmacies) is underway in response to increasing infectious disease incidence. Our results further suggest that the specific dynamics of crystal methamphetamine use, such as propensity for periods of binge use, should be considered in the planning and implementation of expanded harm reduction services (e.g., through peer-based, 24-h supply distribution). NSP expansion efforts should also pay particular attention to the needs of homeless or unstably housed PWID, who were more likely to share syringes in unadjusted analyses.

In addition, supervised injection services, which provide sterile injecting equipment and medically trained staff to supervise injections, are currently being planned as part of the response to drug-related harms in London (Middlesex-London Health Unit 2017; Mitra et al. 2017). In Vancouver, use of such services has been associated with reduced syringe sharing (Kerr et al. 2005), as well as a host of other public health and order benefits (e.g., reductions in fatal overdose (Marshall et al. 2011) and public injecting (Wood et al. 2004)).

Finally, drug selling was independently associated with syringe sharing, and injecting in a place where one buys drugs or pays to use drugs was crudely associated. These findings indicate that interventions focused on engaging people who

sell drugs in the prevention of syringe sharing may be warranted. Models for such engagement include both formalized and unsanctioned secondary syringe distribution hubs in settings where communal use occurs (Wood et al. 2003). Through meaningful engagement, training, and compensation of people who sell drugs and/or operate such spaces, such individuals can be mobilized as resources for HIV, HCV, and overdose prevention. Moreover, illegal income generation strategies including drug dealing are associated with a range of health and social risks for PWID (Kerr et al. 2008). The development of low threshold employment opportunities for PWID has the potential to improve their overall well-being, as well as to reduce engagement in high-risk injection behaviours (Richardson et al. 2012).

Strengths and limitations

Operating within a community-based research framework, the current study involved peer research associates in recruitment and data collection, and was guided by a local community advisory committee. This study recruited participants through city-wide outreach and collected data at three sites, in contrast to the previous study of PWID in London that recruited from a single site (Middlesex-

Table 2 Multivariable logistic regression predicting recent syringe sharing in London, Canada ($n = 198$)

Variable	Adjusted odds ratio (AOR)	95% confidence interval (CI)	<i>p</i> value
Older age (1 year increase)	0.96	(0.92–1.00)	0.056
Homeless or unstably housed (Yes vs. no)	1.51	(0.92–2.47)	0.103
Recent incarceration (Yes vs. no)	1.06	(0.58–1.95)	0.843
Sold drugs (Yes vs. no)	1.92	(1.20–3.08)	<i>0.007</i>
Sex work (Yes vs. no)	1.34	(0.82–2.21)	0.244
Daily number of injections (One-unit increase)	1.03	(1.00–1.07)	0.072
Daily crystal methamphetamine injection (Yes vs. no)	1.66	(1.07–2.59)	<i>0.023</i>
Injected in public (Yes vs. no)	1.23	(0.65–2.33)	0.519
Injected in a place where you buy drugs or pay to use (Yes vs. no)	0.83	(0.51–1.33)	0.431
Didn't know where to get a clean needle when needed (Yes vs. no)	1.01	(0.62–1.64)	0.977
Self-reported HIV-positive (Yes vs. no)	3.11	(1.61–6.01)	<i>< 0.001</i>
Self-reported HCV-positive (Yes vs. no)	1.28	(0.84–1.96)	0.246

Results statistically significant at $p < 0.05$ are indicated in italics

London Health Unit 2012). While this contributed to recruitment of a diverse sample, participants were not randomly sampled and may not be representative of all PWID in London. This study also relied on cross-sectional self-report data, which are subject to response biases and from which causality cannot be inferred. However, PWID self-reports should not be assumed any less valid or reliable than self-reports in general (Darke 1998). Further, as HIV and HCV status were based on self-report, high-risk

syringe sharing (i.e., borrowing by HIV-seronegative and lending by HIV-seropositive individuals) could not be definitely ascertained. We also may have been limited in our ability to detect differences based on infectious disease status due to low counts. In addition, data on the timing of the last HIV/HCV test were not available, and thus, we could not distinguish recent from established infections. For recently diagnosed participants, reported syringe borrowing may have preceded HIV infection.

Table 3 Syringe sharing by self-reported HIV and hepatitis C (HCV) status

Behaviour	HIV-positive ($n = 18$) <i>n</i> (%)	HIV-negative ($n = 165$) <i>n</i> (%)	<i>p</i> value* (HIV+ vs. -)	HCV-positive ($n = 105$) <i>n</i> (%)	HCV-negative ($n = 80$) <i>n</i> (%)	<i>p</i> value (HCV+ vs. -)
Borrowed syringes in past 6 months						
Yes	10 (55.6)	18 (10.9)	<i>< 0.001</i>	23 (21.9)	7 (8.8)	<i>0.016</i>
No	8 (44.4)	147 (89.1)		82 (78.1)	73 (91.3)	
Loaned syringes in past 6 months						
Yes	4 (23.5)	21 (12.7)	0.260	17 (16.4)	7 (8.8)	0.129
No	13 (76.5)	144 (87.3)		87 (83.7)	73 (91.3)	

Results statistically significant at $p < 0.05$ are indicated in italics

*Fisher's exact test due to small expected cell counts

Conclusion

In summary, we found that the prevalence of syringe sharing among PWID in London was higher than that observed among PWID samples in other Canadian cities, likely contributing to the current outbreak of HIV among PWID in London. High-intensity crystal methamphetamine use and selling drugs were independently associated with syringe sharing, and gaps in access to sterile injecting equipment were noted, despite high-volume distribution in London. Taken together, these results support a need for multi-level prevention efforts informed by PWID and people with lived experience, potentially including continued expansion of needle and syringe distribution, engagement of drug sellers in harm reduction, and supervised injection services.

Acknowledgements The authors thank the study participants, research team, and staff, and the study Advisory Committee for their contributions.

Funding information The study was supported by the CIHR Centre for REACH in HIV/AIDS and the Ontario HIV Treatment Network, and Thomas Kerr's CIHR Foundation Grant (20R74326). Ayden Scheim is supported by the Pierre Elliott Trudeau Foundation and a CIHR Fellowship. Geoff Bardwell is supported by a Mitacs Elevate Postdoctoral Fellowship from Mitacs Canada.

Compliance with ethical standards

Participants provided written informed consent and were provided a \$25 honorarium. Ethics approval was obtained from research ethics boards at the University of Toronto and the University of British Columbia.

Conflict of interest The authors declare that they have no conflict of interest.

References

- Bozinoff, N., Wood, E., Dong, H., Richardson, L., Kerr, T., & DeBeck, K. (2017). Syringe sharing among a prospective cohort of street-involved youth: implications for needle distribution programs. *AIDS and Behavior, 21*(9), 2717–2725.
- Campanella, E. (2015). *More than 2.5 million needles distributed in London last year*. London: Free Press Available at: <http://www.lfpress.com/2015/08/13/more-than-25-million-needles-distributed-in-london-last-year>. Accessed 1 June 2017.
- Darke, S. (1998). Self-report among injecting drug users: a review. *Drug Alcohol Depend, 51*, 253–263.
- Gilbert, M. (2015). New HIV diagnoses in Ontario, 2014. Ontario HIV Epidemiology and Surveillance Initiative. Available at: <http://ohesi.ca/documents/OHESI-New-HIV-Diagnoses.pdf>. Accessed 1 June 2017.
- Jenness, S. M., Hagan, H., Liu, K.-L., Wendel, T., & Murrill, C. S. (2011). Continuing HIV risk in New York City injection drug users: the association of syringe source and syringe sharing. *Substance Use & Misuse, 46*(2–3), 192–200.
- Kerr, T., Wood, E., Small, D., Palepu, A., & Tyndall, M. W. (2003). Potential use of safer injecting facilities. *Canadian Medical Association Journal, 169*(8), 759–763.
- Kerr, T., Tyndall, M., Li, K., Montaner, J., & Wood, E. (2005). Safer injection facility use and syringe sharing in injection drug users. *Lancet, 366*(9482), 316–318.
- Kerr, T., Small, W., Johnston, C., Li, K., Montaner, J. S. G., & Wood, E. (2008). Characteristics of injection drug users who participate in drug dealing: implications for drug policy. *Journal of Psychoactive Drugs, 40*(2), 147–152.
- Kerr, T., Small, W., Buchner, C., Zhang, R., Li, K., Montaner, J., et al. (2010). Syringe sharing and HIV incidence among injection drug users and increased access to sterile syringes. *American Journal of Public Health, 100*(8), 1449–1453.
- Kerr, T., Scheim, A. I., Bardwell, G., Mitra, S., Rachlis, B., Bacon, J., et al. (2017). *Ontario integrated supervised injection services feasibility study report: London, ON*. Toronto: Ontario HIV Treatment Network Available at: <http://www.ohtn.on.ca/wp-content/uploads/2017/02/OISIS-London-Report-Online.pdf>. Accessed 1 June 2017.
- Lee, W., Ti, L., Marshall, B. D. L., Dong, H., Wood, E., & Kerr, T. (2015). Childhood sexual abuse and syringe sharing among people who inject drugs. *AIDS and Behavior, 19*(8), 1415–1422.
- Lloyd-Smith, E., Kerr, T., Zhang, R., Montaner, J. S. G., & Wood, E. (2009). High prevalence of syringe sharing among street involved youth. *Addiction Research and Theory, 16*(4), 353–358.
- Marshall, B., Milloy, M.-J., Wood, E., Montaner, J., & Kerr, T. (2011). Reduction in overdose mortality after the opening of North America's first medically supervised safer injecting facility: a retrospective population-based study. *Lancet, 377*(9775), 1429–1437.
- Mathers, B. M., Degenhardt, L., Phillips, B., Wiessing, L., Hickman, M., Strathdee, S. A., et al. (2008). Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review. *Lancet, 372*(9651), 1733–1745.
- Medical Officer of Health. (2016). *Staff report for action on implementing supervised injection services in Toronto*. Toronto: City of Toronto Available at: <http://www.toronto.ca/legdocs/mmis/2016/hl/bgrd/backgroundfile-94548.pdf>. Accessed 1 June 2017.
- Middlesex-London Health Unit. (2013). *A profile of people who inject drugs in London, Ontario: Report on the Public Health Agency of Canada I-Track Survey, Phase 3, Middlesex-London, 2012*. London. Available from: <https://www.healthunit.com/uploads/public-health-agency-of-canada-i-track-survey-phase-3.pdf>. Accessed 1 June 2017.
- Middlesex-London Health Unit. (2014). *The impact of prescription and non-prescription drug use in Middlesex-London*. London. Available from: <https://www.middlesex.ca/council/2014/july/22/C%2012%20-%20C%20W%20Info%20-%20July%2022%20-%20The%20Impact%20of%20Prescription%20and%20Non-Prescription%20Drug%20Use%20in%20Middlesex-London.pdf>. Accessed 1 June 2017.
- Middlesex-London Health Unit. (2017). *Supervised injection services feasibility in Middlesex-London*. London. Available at <https://www.healthunit.com/uploads/2017-02-16-report-005-17.pdf>. Accessed 1 June 2017.
- Mitra, S., Rachlis, B., Scheim, A., Bardwell, G., Rourke, S. B., & Kerr, T. (2017). Acceptability and design preferences of supervised injection services among people who inject drugs in a mid-sized Canadian City. *Harm Reduction Journal, 14*(1), 46.
- Nosyk, B., Zang, X., Min, J. E., Krebs, E., Lima, V. D., Milloy, M.-J., et al. (2017). Relative effects of antiretroviral therapy and harm reduction initiatives on HIV incidence in British Columbia, Canada, 1996–2013: a modelling study. *Lancet HIV, 4*(7), e303–e310.
- Richardson, L., Sherman, S. G., & Kerr, T. (2012). Employment amongst people who use drugs: a new arena for research and intervention? *The International Journal on Drug Policy, 23*(1), 3–5.
- Richmond, R. (2016). *Decrease in London's overdose deaths obscures a growing, longer-term threat from crystal meth*. London Free Press [Internet]. 2016 Mar 17. Available from: <http://www.lfpress.com/>

- 2016/03/17/decrease-in-londons-overdose-deaths-obscures-a-growing-longer-term-threat-from-crystal-meth.
- Richmond, R. (2017). *Health officials plan to add London pharmacies to program that gives clean needles to drug users*. London: Free Press Available from: <http://www.lfpress.com/2017/05/22/health-officials-plan-to-add-london-pharmacies-to-program-that-gives-clean-needles-to-drug-users>. Accessed 1 June 2017.
- SAS Institute Inc. (2013). SAS version 9.4. Cary, NC.
- Schein, A., Rachlis, B., Bardwell, G., Mitra, S., & Kerr, T. (2017). Public drug injecting in London, Ontario: a cross-sectional survey. *CMAJ Open*, 5(2), E290–E294.
- Shaw, S. Y., Shah, L., Jolly, A. M., & Wylie, J. L. (2007). Determinants of injection drug user (IDU) syringe sharing: the relationship between availability of syringes and risk network member characteristics in Winnipeg, Canada. *Addiction*, 102(10), 1626–1635.
- Shaw, A., Lazarus, L., Pantalone, T., LeBlanc, S., Lin, D., Stanley, D., Chepesiuk, C., Patel, S., Tyndall, M., & and The PROUD advisory committee. (2015). Risk environments facing potential users of a supervised injection site in Ottawa, Canada. *Harm Reduction Journal*, 12, 49.
- Statistics Canada. (2013). Health regions and peer groups. Ottawa. Available at <http://www.statcan.gc.ca/pub/82-402-x/2013003/regions/hrpg-eng.htm>. Accessed 17 January 2017.
- Statistics Canada. (2017). Income highlight tables, 2016 census. Ottawa. Available at <http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/inc-rev/Table.cfm?Lang=Eng&T=307&S=123&O=D&RPP=25>. Accessed 17 January 2017.
- Tyndall, M. W., Currie, S., Spittal, P., Li, K., Wood, E., O'Shaughnessy, M. V., et al. (2003). Intensive injection cocaine use as the primary risk factor in the Vancouver HIV-1 epidemic. *AIDS*, 17(6), 887–893.
- van Buuren, S. (2007). Multiple imputation of discrete and continuous data by fully conditional specification. *Statistical Methods in Medical Research*, 16(3), 219–242.
- Wood, E., Tyndall, M. W., Spittal, P. M., Li, K., Hogg, R. S., Montaner, J. S., et al. (2002). Factors associated with persistent high-risk syringe sharing in the presence of an established needle exchange programme. *AIDS*, 16(6), 941–943.
- Wood, E., Kerr, T., Spittal, P. M., Small, W., Tyndall, M. W., O'Shaughnessy, V., et al. (2003). An external evaluation of a peer-run “unsanctioned” syringe exchange program. *Journal of Urban Health*, 80(3), 455–464.
- Wood, E., Kerr, T., Small, W., Li, K., Marsh, D. C., Montaner, J. S. G., et al. (2004). Changes in public order after the opening of a medically supervised safer injecting facility for illicit injection drug users. *Canadian Medical Association Journal*, 171(7), 731–734.
- Wood, E., Li, K., Small, W., Montaner, J. S., Schechter, M. T., & Kerr, T. (2005). Recent incarceration independently associated with syringe sharing by injection drug users. *Public Health Reports*, 120(2), 150–156.