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Community mapping of sex work criminalization and violence: Impacts on HIV treatment interruptions among marginalized women living with HIV in Vancouver, Canada

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Abstract

Despite the high HIV burden faced by sex workers, data on access and retention in antiretroviral therapy (ART) are limited. Using an innovative spatial epidemiological approach, we explored how the social geography of sex work criminalization and violence impacts HIV treatment interruptions among sex workers living with HIV in Vancouver over a 3.5-year period. Drawing upon data from a community-based cohort (AESHA, 2010-2013) and linked external administrative data on ART dispensation, GIS mapping and multivariable logistic regression with generalized estimating equations to prospectively examine the effects of spatial criminalization and violence near women's places of residence on 2-day ART interruptions. Analyses were restricted to 66 ART-exposed women who contributed 208 observations and 83 ART interruption events. In adjusted multivariable models, heightened density of displacement due to policing independently correlated with HIV treatment interruptions (AOR: 1.02, 95% CI: 1.00-1.04); density of legal restrictions (AOR: 1.30, 95% CI: 0.97-1.76) and a combined measure of criminalization/violence (AOR: 1.00, 95% CI: 1.00-1.01) were marginally correlated. The social geography of sex work criminalization may undermine access to essential medicines, including HIV treatment. Interventions to promote 'enabling environments' (e.g., peer-led models, safer living/working spaces) should be explored, alongside policy reforms to ensure uninterrupted treatment access.

Keywords

antiretroviral therapy; HIV; sex work; spatial mapping; criminalization; structural determinants

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INTRODUCTION

In recent years, there has been mounting interest in the influence of ‘place’ (i.e., features of the urban landscape and their geographic distribution) within public health. Previous work has shown HIV/sexually transmitted infection (STI) risks, drug-related harms, and low healthcare access to be concentrated in neighborhoods characterized by greater deprivation (e.g., physical dilapidation, crime and violence, racial inequities), particularly among key populations including people who inject drugs (PWID), men who have sex with men (MSM), and adolescents (1-8).

While geographic approaches have been increasingly used to examine the influence of ‘place’ on HIV/STI risks, spatial influences on HIV treatment access and outcomes remain poorly understood, particularly for key populations. Previous studies report significant geographic clustering of HIV and STIs according to sex work establishments (9) and drug injection sites in Mexico (10) U.S. studies have identified links between neighborhood-level racial inequities, socioeconomic deprivation, and unemployment and poor access and outcomes of the HIV ‘cascade of care’ (11, 12)

Recent efforts to scale-up engagement in the HIV ‘cascade of care’, including uptake and retention in antiretroviral therapy (ART), recognize the importance of addressing gaps experienced by key populations, including sex workers (SWs), who face a disproportionate HIV burden.(13, 14). Understanding and developing strategies to address structural barriers to ART use and retention for key populations currently represent priorities within the global HIV/AIDS movement.(14-16) Previous work has elucidated how spatial clustering of criminalization (e.g., police crackdowns) and violence shape HIV/STI risks and harm reduction access among SWs (17, 18) and PWID.(1) However, previous studies of SWs’ engagement in ART have primarily focused on clinical/behavioral determinants,(19) with limited attention to structural factors.

In British Columbia (BC), Canada, ART is available free-of-charge through universal health coverage. Since 2010, ART access has been scaled-up through provincial ‘treatment as prevention’ coupled with harm reduction and prevention services, which aim to curb HIV morbidity and mortality among key populations, namely PWID and MSM, while reducing population-level HIV transmission.(20) In Canada, as in most other contexts, SWs are criminalized through laws surrounding the sale, advertisement, and purchase of sex (e.g., procuring, third party advertisement, public solicitation in certain areas) (21). The enforcement of such laws have been shown to undermine HIV/STI prevention and safety by promoting rushed condom negotiations and client screening, and displacing SWs to unsafe environments, away from health services.(17, 22-24) Given gaps in evidence on impacts of criminalization on SWs’ use of ART and ongoing efforts to scale-up ART in BC, we used an innovative spatial approach to investigate the independent effects of spatial criminalization and violence (i.e., policing, legal restrictions, workplace violence) on ART interruptions among marginalized SWs living with HIV over a 3.5-year period.

METHODS

Data collection

Prospective interview and mapping data were drawn from a community-based cohort of street and off-street SWs (An Evaluation of Sex Workers' Health Access, AESHA) and with informed consent, linked administrative data on ART dispensation (98%). AESHA is based on longstanding collaborations with sex work, women's and HIV service agencies (25), including a Community Advisory Board of >15 organizations. The study holds ethical approval with the Providence Health Care/University of British Columbia Research Ethics Board, and follows guidelines for community-based sex work research.(26)

Between January 2010-August 2013, 723 women were enrolled in the AESHA cohort, who complete questionnaires at baseline and semi-annually. Given the challenges of recruiting SWs in isolated and hidden locations (27), time-location sampling was used to recruit participants, which is a recruitment method designed to reach hidden populations at the times and places where they are most likely to congregate (28). Indoor sex work venues and outdoor solicitation spaces ('strolls') were identified through community consultation and mapping (25) and updated by the outreach team on an ongoing basis. Using these maps, participants were recruited through weekly daytime and nighttime outreach to diverse venues across Metro Vancouver, including outdoor/public (e.g., streets, alleys), off-street (e.g., online, newspaper advertisements) and indoor spaces (e.g., larger as well as smaller managed, in-call and informal indoor spaces, including massage parlours, micro-brothels, supportive housing).

Eligibility criteria included cisgender and transgender women, aged 14 years, exchanged sex for money within the last month at baseline, and able to provide informed consent. Annual retention of participants under active follow-up is >90%, which is achieved through strong community connections, mobile outreach/interview teams, and collection of updated participant contact information. Following informed consent, participants completed interviewer-administered questionnaires by trained female interviewers (experiential (SWs) and non-experiential women with strong community experience) at study offices or a confidential space of participants' choosing, as well as pre/post-test counseling and testing for HIV/STIs by a nurse (29, 30). Among women living with HIV, HIV disease progression was monitored through CD4 and RNA viral load testing by nurses or linked results from providers. Nursing staff provided referrals and active connections to HIV services and free STI testing and pap smears were offered, regardless of enrolment.

Time-fixed variables derived from questionnaires included socio-demographic characteristics (e.g., age, education, ethnicity). All other variables were considered as *time-updated variables* of events at each semi-annual study visit within the last 6 months. These included injection and non-injection drug use (excluding cannabis, alcohol); inconsistent condom use with clients ('usually', 'sometimes', 'occasionally', or 'never' using condoms for vaginal/anal sex); primary place of service (e.g., outdoor/public, informal indoor, formal/in-call establishment); homelessness (i.e., homeless or slept on street); workplace physical/sexual violence by clients (including abducted/kidnapped, forced unprotected sex,

raped, strangled, physical assault, assaulted with a weapon); violence by police, third parties and strangers; and incarceration (i.e., detained, in prison, or in jail overnight or longer).

Spatial variables were derived from participants' individual questionnaire responses. At each semi-annual visit, as part of the AESHA questionnaire participants were asked about the geographic locations of their place of residence (e.g., hotel, shelter, transitional housing) and events of: i) workplace physical/sexual violence by clients and police; ii) displacement due to policing; iii) community harassment (verbal/physical threats by community residents or businesses); and iv) legal "red zone" restrictions on places where SWs may operate. Trained interviewers used printed maps to identify geographic locations of these events (e.g., cross-streets or exact locations) with participants, as needed. All time-updated spatial data were geocoded at data entry and mapped using ArcGIS.(31) Geocoded measures were used to create a continuous geographic 'surface' for each variable using the kernel density function. (31) A combined geographic measure of criminalization and violence was derived, defined as density of dislocation due to policing, workplace physical/sexual violence, community harassment, police harassment, and legal "red zone" restrictions. Buffers of 250, 500, and 750-meters of participant's home were overlaid on the kernel density 'surface' and density of each measure was calculated within these buffers (i.e., the average value of the kernel density 'surface'). This analysis reports a 250-meter buffer to capture SWs' most proximal neighborhood environment (i.e., <5 minutes walking time, or a few city blocks), given evidence highlighting the importance of proximal environments in shaping HIV-related risks in Vancouver's concentrated inner-city Downtown Eastside.(1)

ART Interruption Analysis

Analyses were restricted to 66 participants. Given the focus of this analysis on ART interruptions, analyses were restricted to women living with HIV who had used ART prior to enrolment or during follow-up. Additionally, given our focus on the spatial environment surrounding women's residential neighborhood, women who identified a place of residence that could be geocoded (i.e., location of transitional housing, shelters, single room occupancy hotels, supportive housing, apartments, homes, or residential locations identified by homeless women) were included. Four women living with HIV who did not use ART or who did not provide a fixed residential location that could be mapped were excluded.

The time-updated outcome measure was ART interruption, defined as 2 consecutive days where no ART was dispensed at each semi-annual visit, following prior ART use. This is consistent with earlier work showing that a large proportion of interruptions fall within this range (32) and evidence that even 2-3 day interruptions may increase viral load and risk of virologic failure (33, 34), although newer treatment regimens may be more forgiving for brief treatment interruptions (35). ART pharmacy dispensation data was accessed via confidential linkage to a provincial health administrative database managed by the BC Centre for Excellence in HIV/AIDS Drug Treatment Program (DTP), for participants who consented to such linkages (>98%). As previously described (36-38), the DTP collects comprehensive information on province-wide ART dispensation as well as HIV/AIDS monitoring information (e.g., CD4 cell counts, plasma viral load). At the time of study, provincial eligibility for ART included all HIV-positive individuals with a CD4 count 500

and other key health indicators and risks (e.g., AIDS-defining illnesses, HCV co-infection, pregnant women, serodiscordant couples), consistent with WHO guidelines. Early entry into ART regardless of CD4 count continues to be encouraged by provincial guidelines.(39)

Using ArcGIS, we developed kernel density maps to visually examine the density of spatial measures of criminalization and client and community violence and harassment surrounding women's residential locations, as well as the distribution of ART interruptions (Figure 1). Following this, descriptive statistics were calculated for key independent variables of interest and potential confounders, stratified by treatment interruptions. Differences between groups were assessed using the Mann-Whitney test for continuous variables and Pearson's Chi-square test (or Fisher's exact test for small cell counts) for categorical variables. Next, we used bivariate and multivariable generalized estimating equations (GEE) with a logit function and an exchangeable correlation structure (40, 41) to examine the relationship between independent variables (i.e., potential confounders, spatial criminalization and violence measures) and treatment interruptions. Variables hypothesized *a priori* to be related to ART interruptions and significant at $p < 0.10$ in bivariate GEE analyses were considered in multivariable models. Bivariate and multivariable GEE analyses included data from baseline and follow-up visits; socio-demographic characteristics were considered as fixed covariates, and all other variables as time-updated covariates of events within the last 6 months.

Separate multivariable GEE confounder models were developed to examine the independent confounding effect of exposure to spatial measures of criminalization and violence (i.e., physical displacement due to policing, 'red zone' legal restrictions, and a combined spatial measure of criminalization and violence) on treatment interruptions over the study period, after adjusting for key confounders. As previously (29, 42), multivariable models were developed using the confounder modeling approach described by Maldonado and Greenland.(43) Analyses were performed using SAS v9.3 (SAS, Cary, NC). All p-values are two-sided.

RESULTS

66 ART-exposed women living with HIV were included in the analysis, contributing 208 observations over 3.5 years' follow-up. Participants completed a median of 3 surveys (inter-quartile range (IQR): 2-5), with a median follow-up duration of 18.4 months (IQR: 11.2-24.7) among those who returned for at least one follow-up. 44 (66.7%) women experienced HIV treatment interruptions, contributing 83 treatment interruption events over the 3.5-year period, whereas the remainder of participants did not experience treatment interruptions and routinely picked up their medications throughout the study period.

Baseline characteristics

The median age was 35.5 years old (IQR: 31.0-43.0); 42 (63.6%) women identified as of Indigenous (i.e., First Nations, Inuit or Métis) ancestry, and nearly all were Canadian-born (Table 1). The median duration since participants were first diagnosed as HIV-positive was 8.3 years (IQR: 2.8-12.5). In comparison with participants without ART interruptions, those

with interruptions had a higher baseline plasma viral load (median: 3.2 $\log_{10}$ copies/mL vs. 1.6 $\log_{10}$ copies/mL).

Approximately one-third (31.8%) of participants had been recently homeless, and this was significantly more likely among women who also experienced ART interruptions (44.1% vs. 18.8%). Most participants (77.3%) lived in Vancouver's downtown eastside neighborhood and serviced clients primarily in outdoor/public (40.9%) or informal indoor (40.9%) spaces. Recent non-injection (90.9%) and injection (63.6%) drug use was high and did not significantly differ by ART interruptions.

Spatial analysis

Figure 1 depicts the density of spatial measures of criminalization and community and client-perpetrated violence surrounding women's residential locations, as well as the density and geographic distribution of treatment interruptions. Geographic mapping revealed the highest density of spatial criminalization and violence within the Northeastern part of Vancouver's Downtown Eastside neighborhood (Figure 1, inset map), with the areas in red constituting the greatest concentration of spatial threats. Similar patterns were noted for each spatial measure when mapped individually. The greatest concentration of treatment interruptions was also observed within the same area, which represents where HIV and harm reduction services are most concentrated, including the most common sites where participants picked up their treatment (i.e., ART providers accessed by 71.2% of SWs). The median walking time between participants' place of residence and ART pickup location was 14.07 minutes (IQR: 5.51-48.27), which did not significantly differ by treatment interruptions.

In bivariate GEE analysis, increased density of displacement due to policing (Odds Ratio (OR): 1.02, 95% Confidence Interval (CI): 1.01-1.04), workplace physical/sexual violence (OR: 1.01, 95%CI: 1.00-1.02), legal 'red zone' restrictions (OR: 1.34, 95%CI: 1.02-1.75) and a combined measure of spatial criminalization and violence (OR: 1.00, 95%CI: 1.00-1.01) within a 250-meter buffer of a woman's home were independently correlated with treatment interruptions (Table 2).

In multivariable GEE models adjusted for key confounders (i.e., age, homelessness, injection drug use, duration of known HIV positivity), increased density of displacement due to policing (AOR: 1.02, 95%CI: 1.00-1.04, $p=0.014$, Table 3) within a 250-meter buffer of women's home was independently correlated with ART interruptions over time. Additionally, increased density of legal "red zone" restrictions (AOR: 1.30, 95%CI: 0.97-1.76, $p=0.083$, Table 4) and a combined measure of spatial criminalization and violence (AOR: 1.00, 95%CI: 1.00-1.01, $p=0.069$, Table 5) were marginally correlated.

DISCUSSION

In this study, over two-thirds of women SWs living with HIV who previously used antiretroviral therapy (ART) experienced treatment interruptions of two days or longer over a 3.5-year period. Despite the existence of universal healthcare access (including free ART), progressive harm reduction models, and ongoing 'treatment as prevention' HIV efforts in

BC, SWs living with HIV continue to face serious gaps related to their sustained engagement and use of ART, as well as other health services (30, 44). Nonetheless, as one-third of participants did not experience treatment interruptions and routinely picked up their medications, future research involving populations of SWs and marginalized women who are successfully engaged and retained in ART is recommended to inform interventions and best practices.

This study documented an independent geographic association between displacement due to policing within SWs' residential environment and HIV treatment interruptions, independent of drug use. Our findings demonstrate the impacts of enforced neighborhood-level criminalization and displacement of marginalized women living with HIV in undermining engagement in life-saving treatment. While previous studies have demonstrated how criminalization (14, 18, 37, 45-47) and violence (1, 14, 18, 48) can foster marginalization, displacement from health/social services, and exacerbate HIV risk among SWs and PWID, few have examined these influences among women living with HIV. Our findings are supported by research among street-based SWs in Vancouver, which detected a significant geographic relationship between a concentrated area of harm reduction services and avoidance of physical settings due to violence and policing.(18) These findings illustrate how social geographic factors such as enforced criminalization may inadvertently undermine access to essential, life-saving health services and medicines. While future studies remain needed to elucidate the pathways through which criminalization may undermine sustained use of ART, anecdotal community reports suggest that women who are heavily policed often have their daily routines negatively affected by policing, leading to disruptions in healthcare access (e.g., via displacement away from providers or one's home where prescriptions are kept).

Study findings indicate the need for innovative, community-based strategies to support safe, voluntary, and uninterrupted access to ART for women living with HIV. Evidence suggests that when appropriate supports are provided, SWs can be effectively engaged in HIV care (49) and achieve adherence (50) rates similar to, if not better than, the general population. (19) Although interventions to promote engagement and adherence to ART for SWs have been less-often studied than primary prevention approaches (51), current evidence suggests that peer-led services and community-based outreach may be effective strategies.(50-53) Critical to creating an 'enabling environment' for sustained ART use and improved virologic outcomes are policy reforms to shift away from criminalized approaches to sex work, HIV status, and drug use, towards models which prioritize wellbeing and human rights. Although social cohesion and the ability to self-organize remain key to the success of the most effective HIV interventions in sex work,(52, 54) criminalization and social exclusion continue to limit this in many settings, such as through recent Canadian legislation which undermine SWs' abilities to organize and access health/social services.(22)

This study was limited by the small number of HIV-seropositive SWs who provided geographic data (e.g., place of residence), although this would have biased our findings towards the null. Given the current lack of data on structural interventions to enhance SWs' engagement and outcomes of ART, future studies which build on these findings and involve larger cohorts of women living with HIV are needed. Our analysis focused on spatial

exposures surrounding participants' place of residence, given strong evidence of the importance of neighborhood environments for health access and outcomes for marginalized populations. Although previous work has shown that marginalized women in Vancouver's concentrated Downtown Eastside neighborhood often live and work within the same space (e.g., supportive housing models or single-room occupancy hotels)(55), or in areas located very close to their place of residence (e.g., within a few blocks' distance), future studies analyzing spatial exposures within SWs' proximal work environment are recommended. Additionally, our geographic measures of violence did not include intimate partner violence given we focused on community and workplace measures, but could also be an important area for future studies. Finally, ART use was measured using comprehensive prescription refill data, rather than using viral load data or directly observed therapy. While this has been found to be more reliable than self-report (56-58) and commonly used measures of ART adherence, it may overestimate actual use; future spatial studies using biomarkers such as viral load are recommended.

To conclude, we found that spatial measures of sex work criminalization and violence contribute to HIV treatment interruptions among SWs living with HIV. These findings highlight how the enforcement of laws and policies criminalizing sex work undermine health and human rights for women living with HIV. Interventions to promote 'enabling environments' (e.g., sex worker/peer-led models, safer living/working spaces) should be explored, alongside policy reforms to support marginalized women's access to essential medicines, including ART.

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Figure 1. Relationship between density of spatial criminalization and ART interruptions among marginalized women living with HIV (n=66) in Metropolitan Vancouver, Canada, at baseline*

*Note: The primary map includes data from the entire Metropolitan Vancouver area. The inset map provides a zoomed-in image depicting in greater detail the density of spatial threats and ART interruptions within the City of Vancouver's Downtown Eastside neighborhood, where HIV and drug-related harms are largely concentrated and where most participants' ART prescriptions were filled.

Table 1

Baseline Characteristics of Marginalized Women Living with HIV (N=66), Metropolitan Vancouver, Canada, 2010-2013

Variable	ART Interruption		Total n (%) N=66	p value
	Yes n (%) n = 34	No n (%) n = 32		
Age, in years (<i>median, IQR</i>)	37.5 (28.0-43.0)	35.0 (31.5-42.5)	35.5 (31.0-43.0)	0.868
Indigenous	23 (67.7%)	19 (59.4%)	42 (63.6%)	0.485
High school education	9 (26.5%)	14 (43.8%)	23 (34.9%)	0.141
Duration of known HIV positivity, in years (<i>median, IQR</i>)	9.1 (2.1-14.2)	7.7 (3.2-12.4)	8.3 (2.8-12.5)	0.739
CD4 cell count, in cells/mm ³ (<i>median, IQR</i>)*	328 (130-450)	445 (305-575)	365 (240-500)	0.026
HIV RNA plasma viral load, in log ₁₀ -copies/mL (<i>median, IQR</i>)*	3.2 (1.9-4.5)	1.6 (1.5-3.3)	2.2 (1.5-4.3)	0.005
Average monthly income* (<i>CAD</i>)	\$1500 (\$400-	\$1680 (\$600-	\$1640 (\$450-	0.872
Average monthly client volume (<i>median, IQR</i>)*	24.0 (12.0-56.0)	24.0 (9.0-48.0)	24.0 (10.0-48.0)	0.823
Inconsistent condom use with clients*	6 (17.7%)	3 (9.4%)	9 (13.6%)	0.302
Non-injection drug use*	30 (88.2%)	30 (93.8%)	60 (90.9%)	0.673
Injection drug use*	20 (58.8%)	22 (68.8%)	42 (63.6%)	0.402
Homelessness*	15 (44.1%)	6 (18.8%)	21 (31.8%)	0.027
Lives in Downtown Eastside*	27 (79.4%)	24 (75.0%)	51 (77.3%)	0.669
Place of service				0.214
<i>Outdoor/public (ref)</i>	13 (38.2%)	14 (43.8%)	27 (40.9%)	
<i>Informal indoor establishment</i>	16 (47.1%)	11 (34.4%)	27 (40.9%)	0.414
<i>In-Call/ Formal SW establishment</i>	1 (2.9%)	5 (15.6%)	6 (9.1%)	0.186

* In the last 6 months

IQR: Inter-quartile range

NOTE: All values refer to n (%) of participants, unless otherwise specified.

Table 2

Bivariate GEE Analysis of Associations Between Spatial Measures of Criminalization and 2 Day ART Interruptions among Marginalized Women Living with HIV (N=66) in Metropolitan Vancouver over time, 2010-2013

Variable	Odds Ratio	95% Confidence Interval
Density of displacement due to policing *	1.02	1.01-1.04
Density of workplace physical/sexual violence *	1.01	1.00-1.02
Density of community harassment *	1.02	0.99-1.04
Density of police arrest/harassment *	1.01	1.00-1.02
Density of 'red zone' / legal restrictions on work areas *	1.34	1.02-1.75
Density of combined spatial criminalization measures *	1.00	1.00-1.01

* Measured within a 250 meter buffer of one's residential location

Table 3

Confounder GEE Model of Relationship Between Police Displacement and 2 Day ART Interruptions among Marginalized Women Living with HIV (N=66), Metropolitan Vancouver, Canada, 2010-2013

2 Day ART Interruption		
Variable	Adjusted Odds Ratio (95% Confidence Interval)	<i>p-value</i>
Density of displacement due to policing, within 250 meters of residence	1.02 (1.00-1.04)	<i>0.014</i>

* Model adjusted for homelessness in the last 6 months and duration of known HIV-positive status. Other variables adjusted for, but which were removed during the backwards selection process included age and injection drug use in the last 6 months.

Table 4

Confounder GEE Model of Relationship Between ‘Red Zone’/Legal Restrictions and 2 Day ART Interruptions among Marginalized Women Living with HIV (N=66), Metropolitan Vancouver, Canada, 2010-2013

2 Day ART Interruption		
Variable	Adjusted Odds Ratio (95% Confidence Interval)	<i>p-value</i>
Density of ‘red zone’/legal restrictions on work areas, within 250 meters of residence	1.30 (0.97-1.76)	<i>0.083</i>

* Model adjusted for homelessness in the last 6 months. Other variables adjusted for, but which were removed during the backwards selection process included age, injection drug use in the last 6 months, and duration of known HIV-positive status.

Table 5

Confounder GEE Model of Relationship Between a Combined Measure of Spatial Criminalization and Violence and 2 Day ART Interruptions among Marginalized Women Living with HIV (N=66), Metropolitan Vancouver, Canada, 2010-2013

2 Day ART Interruption		
Variable	Adjusted Odds Ratio (95% Confidence Interval)	p-value
Density of combined spatial criminalization, within 250 meters of residence	1.00 (1.00-1.01)	0.069

* Model adjusted for homelessness in the last 6 months. Other variables adjusted for, but which were removed during the backwards selection process included age, injection drug use in the last 6 months, and duration of known HIV-positive status.