Published in final edited form as:

J Acquir Immune Defic Syndr. 2015 December 1; 70(4): 420–427. doi:10.1097/QAI.0000000000000769.

HIV prevalence, estimated incidence, and risk behaviors among people who inject drugs in Kenya

Ann E. Kurth, PhD, CNM, MPH[*], **Charles M. Cleland, PhD**[*], **Don C. Des Jarlais, PhD**[§], **Helgar Musyoki**[¶], **John A. Lizcano, MPH**[*], **Nok Chhun, MS, MPH**[*], and **Peter Cherutich, MBChB, MPH**[¶]

[*]New York University College of Nursing, New York, NY, USA

[§]The Baron Edmond de Rothschild Chemical Dependency Institute, Mount Sinai Beth Israel, New York, NY, USA

[¶]National AIDS & STI Control Programme (NASCOP), Nairobi, Kenya

Abstract

Objective—HIV infection in sub-Saharan Africa increasingly occurs among people who inject drugs (PWID). Kenya is one of the first to implement a national needle and syringe program (NSP). Our study undertook a baseline assessment as part of evaluating NSP in a seek, test, treat, and retain approach.

Methods—Participants enrolled May–December 2012 from 10 sites. Respondent-driven sampling was used to reach n=1,785 PWID for HIV-1 prevalence and viral load determination and survey data.

Results—Estimated HIV prevalence, adjusted for differential network size and recruitment relationships, was 14.5% in Nairobi (95% CI 10.8–18.2) and 20.5% in the Coast region (95% CI 17.3–23.6). Viral load (log_{10} transformed) in Nairobi ranged from 1.71 to 6.12 (median 4.41; IQR

Corresponding Author: Ann E. Kurth, PhD, CNM, MPH, New York University College of Nursing, 433 First Avenue, 6th Floor, New York, NY 10010, Phone: 212-998-5316, akurth@nyu.edu.

Conflicts of Interest: The authors have no conflicts of interest to disclose.

Author Contributions: Dr. Kurth had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Kurth, Cherutich.
Analysis and interpretation of data: Kurth, Cleland, Des Jarlais.
Statistical analysis: Cleland.
Drafting of the manuscript: Kurth, Cleland, Cherutich, Chhun, Lizcano.
Critical revision of the manuscript for important intellectual content: All authors.

List of Supplemental Digital Content:
Supplemental Digital Content 1.doc
Supplemental Digital Content 2.doc
Supplemental Digital Content 3.doc
Supplemental Digital Content 4.doc
Supplemental Digital Content 5.doc
Supplemental Digital Content 6.doc
Supplemental Digital Content 7.doc
Supplemental Digital Content 8.doc
Supplemental Digital Content 9.doc
Supplemental Digital Content 10.doc

3.51–4.94) and in the Coast from 1.71 to 5.88 (median 4.01; IQR 3.44–4.72). Using $\log_{10}$ viral load 2.6 as a threshold for HIV viral suppression, the percentage of HIV-infected participants with viral suppression was 4.2% in Nairobi and 4.6% in the Coast. Heroin was the most commonly injected drug in both regions, used by 93% of participantsin the past month typically injecting 2–3 times/day. Receptive needle/syringe sharing at last injection was more common in Nairobi (23%) than the Coast (4%). Estimated incidence among new injectors was 2.5/100 person-years in Nairobi and 1.6/100 person-years in the Coast.

Conclusion—The HIV epidemic is well-established among PWID in both Nairobi and Coast regions. Public health scale implementation of combination HIV prevention has the potential to greatly limit the epidemic in this vulnerable and bridging population.

Keywords

HIV; injection drug use; sub-Saharan Africa; needle syringe program

INTRODUCTION

Little has been published on injection drug use in sub-Saharan Africa, where HIV continues to be a leading cause of death and disability.[1,2] In Kenya, where the epidemic is largely driven by sexual transmission, parenteral transmission is increasingly becoming recognized;[3,4] an estimated 18.7% of incident HIV infections on the Kenyan coast and 7.5% nationally are attributed to people who inject drugs (PWID).[5] However, evidence-based prevention and care for PWID including needle syringe programs (NSP) and PWID-specific antiretroviral therapy (ART) support have been nearly non-existent in this region.[6] Recent size estimation in Kenya revealed a growing PWID population, high background HIV prevalence,[7] and high risk behaviors.[8,9]

PWID are highly vulnerable to HIV and can be a bridge for HIV transmission to general populations. Needle sharing[10,11] and other high risk behaviors (including ‘flashblood’ where in users who cannot afford heroin inject the blood of a PWID who recently injected), are common.[12,13] HIV prevalence among PWID in sub-Saharan Africa is estimated to range from 5.5% to 42.9%.[14] In Kenya, PWID HIV prevalence is estimated at 18% versus 5.6% in the general population; 29.8% reported sex without a condom in the past month; 51.6% reported use of sterile injecting equipment the last time they injected.[15] An analysis of a multi country survey found that 12 of 14 (86%) female injectors in Nairobi engaged in sex work.[16] In sub-Saharan Africa, the region with highest HIV prevalence globally, injectors can exacerbate HIV epidemics, given the rapid nature that is the hallmark of HIV epidemics among PWID.[14,17]

Key interventions are highly effective in reducing risk of HIV acquisition (male circumcision, pre-exposure prophylaxis) and transmission (early initiation of ART), especially when used in a ‘combination prevention’ approach.[18] Nine evidence-based interventions have been endorsed for prevention, treatment, and care of HIV in PWID,[19]with NSP, opioid substitution therapy (OST), and ART for HIV-positives recommended as an international minimum standard. Pre-exposure prophylaxis (PrEP) use has been recommended by the Centers for Disease Control and Prevention as a potential

option to reduce HIV among high-risk PWID,[20] though PrEP has not yet been widely implemented in many countries.[21] The World Health Organization (WHO) notes that NSPs are effective in reducing HIV transmission,[22] especially in high income countries.[23–26] NSP scan be effective in reducing HIV in lower-income country settings if implemented on a public health scale,[23,27,28] and OST can also be effective for reducing illicit drug use and associated HIV risk behavior in middle/low income settings if implemented according to WHO guidelines.[29,30] Still, interventions in low/middle income countries do not have the benefit of high income countries' more available resources, stronger health systems, and generally stable policy structures that influence HIV epidemic control, so that additional research on controlling HIV among PWID in transitional/low/middle income countries is clearly needed.

In 2013 Kenya implemented NSP at a country-wide level. This paper is one of the first to describe baseline PWID risks prior to evaluating the potential effect of NSP in this key population. Our study leverages the Government of Kenya's decision to launch NSP for PWID. Using time series and stepped wedge cluster-randomized design elements, our 'TLC-IDU'study will provide among the first data regarding implementation of a 'seek, test, treat, and retain' approach to PWID in sub-Saharan Africa.[31] Lessons learned will inform how Kenya and other countries in the region can best address the growing PWID contribution to the HIV epidemic. We present baseline data on HIV prevalence, estimated incidence, drug use and injecting behaviors, sexual risk behaviors, and viral load distribution among the PWID population in Kenya in Nairobi and the Coast region and consider possible future HIV transmission in these areas.

METHODS

Study sites

Study participants were recruited from tensites that were implementing partners for Kenya's NSP program working with PWIDin Nairobi or Coast regions. Site sample sizes ranged from 86 to 231 (median = 204.5), with 663 PWID enrolled in Nairobi and 1,122 enrolled in the Coast region between May 2012 and December 2012.Out of the ten study sites, four are in Nairobi and six in Coastal Mombasa. The four study sites in Nairobi, being more urban, are in close proximity, while most of the six study sites in Coastal Mombasa are spread apart from each other. In the beginning of the government's NSP rollout there was some opposition from religious leaders in Coast, especially from the Muslim community. However with sensitization and engagement, the community became accepting of needed services for PWID. Most sites are close to location where drug sales and injecting bases exist, which facilitates active PWID to approach program sites for services, such as NSP and others. Though there is some variability across sites in Nairobi and Coast, most sites offer the WHO-recommended nine elements package of PWID services. Most of the study's partner sites have a growing infrastructure and supportiveness for prevention, treatment and care of PWID. Only two of the partner sites do not offer direct services for PWID as they are hospitals, therefore, study participants from those two sites seek PWID services at other sites.

Sampling design and recruitment

Inclusion Criteria—Participants were at least 18 years old, lived in Nairobi or Coast regions, injected non-prescribed drugs at some point in their lifetime, and used non-prescribed drugs by any route of administration in the past year. Potential participants were not enrolled if they were under the influence of substances and thus unable to consent, reported being forced to participate, or if the interviewer was not confident that the potential participant was a PWID based on responses to questions about injection drug use particulars as well as visual observation of the skin.

Respondent-Driven Sampling—We used respondent-driven sampling (RDS) to overcome some of the limitations of other sampling methods for hard-to-reach populations. RDS's adaptation of chain referral methods allows for adequate population coverage and calculation of inclusion probabilities for each individual.[32,33] With each inclusion probability known, the proportion of population members with a specific characteristic (e.g., PWID with HIV) can be estimated in an asymptotically unbiased way.[33,34] RDS starts with a number of 'seed' participants, members of the target population who begin the sampling process by recruiting others from their social networks. Each recruit can recruit additional population members. Theoretically, the final sample will be independent of the initial seeds if a sufficient number of recruitment waves are undertaken[33] and sample composition becomes stable despite additional waves of recruitment, a state referred to as "equilibrium".[35] Attainment of equilibrium and independence of the final sample can be facilitated by limiting the number of recruits any one individual can bring in.[36] In our study sites, recruitment was initiated by three to five seeds who were trained to recruit PWID peers using coded recruitment coupons (mean and median of 3 coupons given). Overall ineligibility was 8% (162 of 1947 not eligible), most (69%) because the interviewer was not confident they were a PWID.

Data collection

Biometric data collection—We used biometric (finger print) unique ID generation to prevent more than one enrollment of an individual PWID per study phase and to be able to track repeat visits over the course of the study beyond baseline. We used NCheck (Neurotechnology Inc., Vilna)biometric application and Dropbox (Dropbox Inc., San Francisco) to synchronize ID databases in all the sites in real time.

Handheld-assisted personal interview—Behavioral data were collected by staff-administered survey using encrypted Android tablets with Open Data Kit Collect software (ODK, University of Washington, Seattle). The interview collected demographic information and assessed risks including HIV test history, parenteral and sexual risk behaviors, alcohol/drug use, exposure to services, prevention methods, treatment adherence, and mental health indices. Data from the 1947 enrolled participants were transferred to a secure encrypted server using GSM and 3G networks (Safaricom, Kenya).

Experience and training of interviewers—Study staff were trained in human subject protection in addition to Kenyan program-standards and training for TLC-IDU study procedures. All study staff had national certification for HIV testing and counseling and for

phlebotomy. The National HIV Reference Laboratory in Nairobi conducted quality control proficiency testing of every staff member who conducted HIV testing on a quarterly basis. A booster training was provided to study staff halfway through the baseline period.

Laboratory testing

HIV—After obtaining study consent and completing the survey, staff conducted HIV pre-test counselling, confirmed participant's decision to test and receive results, and carried out HIV testing using a rapid serial assay algorithm following Government of Kenya guidelines. Screening specimens that tested negative using Alere Determine HIV-1/2 Ag/Ab rapid test (Alere Inc., Waltham, MA) were reported as negative. Those who tested positive were confirmed using a second assay, Uni-Gold HIV-1/2 (Trinity Biotech PLC, Wicklow, Ireland). If this second test was positive, the result was reported as positive. When two tests were discordant, specimens were sent to the National HIV Reference Laboratory for enzyme linked immunoassay (ELISA), results of which were reported as the true results and appropriate post-test counselling and referrals was given. Quality control was maintained by collecting a dried blood spot (DBS) on every 20th HIV-negative and every 5th HIV-positive specimen collected, using Vironostika™ HIV-1/2 antigen/antibody and Murex™ HIV.1.2.O in parallel testing.

Viral Load testing—To assess community viral load at baseline, we collected DBS specimens from all HIV-positive participants' fingertips onto What man 903 Specimen Collection paper which was dried overnight then shipped in glycineina zip-lock bag with desiccant and humidity indicator card to the National HIV Reference Laboratory where DBS specimens were stored at −20 degrees Celsius until analyzed. The National HIV Reference Laboratory used the COBAS AmpliPrep/COBAS TaqMan HIV-1 Qualitative Test, version 2.0 (CAP/CTM v2.0) to obtain HIV-1 viral load results. Laboratory staff excised one 12mm circular punch from the What man 903 Specimen Collection paper and placed it into a Sample input tube (S-tube). Afterwards, 1100 µl of Specimen Pre-Extraction Reagent (SPEX) was added to the S-tube containing the circle of the collection paper and incubated in an Eppendorf Thermo mixer comfort at 56 degrees Celsius with continuous shaking at 1000 rpm for 10 minutes. Once specimens were ready, laboratory staff ran the specimens using the COBAS AmpliPrep instrument for automated specimen processing and the COBAS TaqMan analyzer for automated amplification and detection. AMPLILINK Software, 3.3 Series, was needed to run the specimens and determine the results.

Data analysis

Version 0.5 of the RDS R package[37] was used to calculate population estimates of HIV prevalence and other variables while taking into account social network sizes and patterns of recruitment. Version 3.03 of the R statistical computing environment[38] was used for all other analysis. Logistic regression was used to examine bivariate correlates of HIV infection in each study region. Logistic regression was also used to estimate the unique effects of predictors in multivariable models; starting with models containing all main effects, terms were removed from multivariable models using backward elimination of non-significant terms ($p > .05$).

Estimation of HIV incidence among new injectors followed methods employed by Des Jarlais and colleagues.[39] These methods have been used in other recent studies.[40,41] Two opposing factors were considered when deciding which PWID to include in estimates of incidence. Including PWID with more years injecting increases sample size and allows for examination of a key assumption. Including PWID with fewer years injecting reduces the likelihood of differential loss of people with, versus without, HIV infection from the pool of potential recruits. To balance these opposing factors, we included PWID with five or fewer years injecting as "new injectors" contributing to estimation of incidence. These new injectors were defined as those whose age at the time of the survey was no more than five years greater than their reported age at first injection. About two-thirds of all participants were classified as new injectors (n=1185; 66.4%). The incidence estimate assumes the following: 1) all new injectors were uninfected when they began injecting; 2) the number of incident cases among new injectors is equal to the number who tested positive for HIV at the time of the survey; 3) HIV infection among those who tested positive occurred midway between the start of injecting and the time of the survey; 4) the time at risk for new injectors testing negative was the total time from first injection to the survey; and 5) there was no differential loss of HIV-positives versus HIV-negatives in the PWID population in the short time periods between first injection and time of interview. As the assumption that all subjects were uninfected when they began injecting is not likely to hold for the generalized epidemic in Kenya, we conducted additional analysis of incidence using logistic regression considering the probability of infection before injecting began and the increase in the probability of infection with each year of injecting among new injectors. This approach allowed for estimating incidence due to injection while adjusting for HIV prevalence at the time injection began.

RESULTS

Demographic characteristics

Table 1 describes the age and gender of study participants by study region. Participants were typically young adult males, although the majority was female in one of the ten study sites.

Diagrams for recruitment chains in each study site with HIV status differentiated (uninfected, previously diagnosed, and newly diagnosed) are presented in Supplemental Digital Content Figures 3–12. These figures show discordant recruitment relationships are frequently observed (positive recruiter and negative recruit or negative recruiter and positive recruit). Excluding thirty-one seed participants, about one quarter of all recruitment relationships were HIV discordant (26.2%; 460 of 1754 recruits). In more than half of these HIV discordant recruitment relationships, the recruiter was infected and the recruit was uninfected (56.3%; 259 of 460).

Years Injecting

In the Nairobi region, years injecting ranged from 1 to 37, with a median of two years. One and six years of injecting marked the lower and upper quartiles of years injecting. Thus, 75% of Nairobi participants injected for six or fewer years. In the Coast region, years injecting ranged from 1 to 36, with a median of four years. Two and eight years marked the

lower and upper quartiles of years injecting. Thus, 75% of Coast participants injected for eight or fewer years.

HIV prevalence

Estimated HIV prevalence, adjusted for differential network size and recruitment relationships was 14.5% in Nairobi (95% CI: 10.8–18.2) and 20.5% in the Coast region (95% CI: 17.3–23.6). Population homophily for positive HIV serostatus was 1.21 in Nairobi and 1.27 in the Coast region, which indicates 21–27% more ties with concordant status than would be expected if ties form without regard to HIV infection. Convergence plots were used to determine whether equilibrium was reached in the HIV serostatus estimates in each site. In both regions, estimates of positive HIV serostatus changed little over the last fifty participants recruited.

Estimated HIV incidence among new injectors

The 1185 new injectors across all study sites contributed a total of 2544.5 person-years at risk. A total of 145 of these new injectors had HIV infection at the time of the survey. Therefore, estimated incidence was approximately 5.7per 100PY at risk (95% CI: 4.8 – 6.7). We also estimated incidence only for new male injectors. New male injectors contributed a total of 2253 person-years at risk, and 94 had HIV infection at the time of the survey. Therefore, estimated incidence was approximately 4.2 per 100PY at risk among male new injectors (95% CI: 3.4 – 5.1). The number of new female injectors and total time at risk among new female injectors were not sufficient for estimating incidence, but the difference between total and male incidence suggests incidence among female injectors may be higher.

General population HIV prevalence among young adults in Kenya was 5.6% in 2012,[42] which makes the assumption that all participants were uninfected before they began injecting untenable. Using logistic regression, we estimated that prevalence among PWID was 7.0% in Nairobi and 9.2% in the Coast region before the start of injecting, higher prevalence than the general population before injecting began. As shown in Figure 1, among new injectors, prevalence increased to 19.5% in Nairobi and 17.4% in the Coast region after five years of injecting. Averaging over the first five years of injecting and subtracting estimated prevalence before injecting began, this suggests annual HIV incidence of 2.5% in Nairobi and 1.6% in the Coast region.

Viral load

Results of viral load testing were available for 71 Nairobi participants and 216 Coast participants (71% of 404 participants with HIV). Figure 2 shows distributions of $\log_{10}$ HIV viral load among participants with newly diagnosed and previously diagnosed HIV infection. Viral load ($\log_{10}$ transformed) in Nairobi ranged from 1.71 to 6.12 (median = 4.41; IQR = 3.51 to 4.94). In the Coast region, $\log_{10}$ viral load ranged from 1.71 to 5.88 (median = 4.01; IQR = 3.44 to 4.72). A $\log_{10}$ viral load of 2.6 (i.e., 398 RNA copies per ml) can be used as a threshold for HIV viral suppression.[43] Using this threshold, the percentage of HIV-infected PWID participants with viral suppression was 4.2% in Nairobi and 4.6% in the Coast region.

Sexual risk behaviors

Among all participants, the prevalence of sex without a condom at last sex with a main partner was 18% in Nairobi and 24% in Coast, and the prevalence of sex without a condom at last sex with a casual partner was 5% in Nairobi and 6% in Coast. Among participants sexually active with a main partner (21% in Nairobi and 26% in Coast), the prevalence of sex without a condom at last sex with a main partner was 86% in Nairobi and 87% in Coast. Among participants sexually active with a casual partner (10% in Nairobi and 14% in Coast), the prevalence of sex without a condom at last sex with a casual partner was 54% in Nairobi and 43% in Coast. Average age at sexual debut was similar (16.4 years, SD=3.4 Nairobi and 16.7, SD=3.5 Coast).

Injection drug use and injection risk practices

Heroin was the most commonly injected drug in both Nairobi and Coast, and was the most commonly used drug in the past month for 93% of participants. Participants typically injected 2–3 times per day nearly every day in the past month. Receptive needle/syringe sharing at the last injection was more common in Nairobi (23%) than the Coast region (4%).At the times the surveys took place, there were no active needle and syringe programs in the areas where PWID were recruited. Participants were asked about the sources of their syringes. The most common sources identified were pharmacy (72%), the place where the PWID injects (12%), and dealers (8%).

Correlates of HIV infection

Table 2 presents bivariate correlates of HIV infection. In Nairobi, male gender and age at first injection were associated with reduced odds of infection; PWID social network size, years injecting, injections per day and receptive needle/syringe sharing were associated with increased odds of infection. In Coast, male gender and age at first injection were associated with reduced odds of infection; age, years injecting, number of injections past month, days injecting in past month, injections per day, receptive needle/syringe sharing, receptive sharing of other injecting equipment, and older age at sexual debut were associated with increased odds of infection.

Table 3 presents results of multivariable logistic regression analysis to determine unique predictors of HIV infection. In Nairobi, male gender was associated with reduced odds of infection; years injecting and receptive needle/syringe sharing were associated with increased odds of infection. In Coast, male gender was associated with reduced odds of infection; years injecting, number of injections past month, and receptive needle/syringe sharing were associated with increased odds of infection.

DISCUSSION

In this paper we set out to describe baseline PWID risks prior to evaluation of Kenya's NSP and to gather information regarding potential transmission risks in this high-need key population that can serve as a transmission bridge to general populations. We documented that HIV infection is well-established among PWID in both Nairobi and the Coast region, with prevalence well above that of the general young adult population. HIV prevalence

among PWID in these regions is well above "low" (<5%) though still just below "high" (>20%) designations.[19] Our incidence estimates suggest that HIV is spreading in PWID populations—clearly not zero though also not the 10+/100 person-years associated with extremely rapid PWID transmission. Nonetheless it remains above the levels noted in Kenya among some other key populations such as female sex workers (e.g., in a Mombasa FSW cohort ~3/100 person-years).[44] Targets for HIV risk reduction among Kenyan PWID have been identified by Strathdee and colleagues,[45] as well as incorporated into the national NSP and the HIV Prevention Revolution Roadmap[46] in Kenya.

Injecting risk behaviors, e.g., syringe sharing at last injection, was comparatively moderate, with a lower rate in Coast. The effect of gender in multivariable logistic regression analysis suggests some HIV acquisition may be due to sexual transmission before or after initiation of injecting, but effects of duration and frequency of injection as well as syringe sharing on the probability of HIV infection indicate parenteral transmission as well. The connections between HIV-positive and HIV-negative individuals noted in our RDS recruitment chains (see Figures 3–12, Supplemental Digital Content 1–10, RDS recruitment chains) clearly demonstrate potential additional transmission, including through parenteral and sexual networks.

Limitations

Small sample sizes in some study sites decrease confidence in HIV prevalence estimates based on respondent-driven sampling. The assumption that PWID are uninfected at the start of injecting may be far from reality, as there is a large heterosexual HIV epidemic in Kenya and many participants may have been infected via sexual transmission prior to the start of injecting. If many were HIV-positive when they began injecting, there would probably be greater loss of HIV-positives than HIV-negatives in the injecting population, which would lead to underestimating HIV incidence. We did not observe any PWID who began injecting less than one year ago, which may be related to item wording and coding and could lead to underestimation of HIV incidence.

Summary

In the absence of other specific data, we would predict continued moderate growth in HIV infection among PWID in Kenya. If high-quality combination prevention programs for PWID (including NSP, OST, and ART) are rapidly implemented on a public health scale as planned in Kenya, it should be possible to control the current epidemic. The ability to do so, however, may depend crucially upon the service coverage levels of NSP, OST, ART, and potentially, PrEP, for PWID in Kenya. Combination prevention including evidence-based packages for PWID has been quite successful in reversing high HIV prevalence epidemics in a number of high-income country settings (e.g., Amsterdam, Vancouver, San Francisco). Achieving comparable results in a resource-limited setting such as Kenya would be a major public health achievement.

It is unlikely, however, that HIV prevalence among PWID would approach zero. Residual injecting related transmission of HIV and sexual transmission of HIV among PWID and the entry of HIV seropositive persons into drug injecting are likely to keep HIV prevalence

among PWID at least as high as prevalence among the young adult population. Most concerning, the proportion of HIV-infected PWID who were virally suppressed was under five percent in both study areas, suggesting high levels of circulating virus in this community prior to NSP introduction. This represents a failure of the HIV treatment cascade goal of optimizing identification, treatment engagement and successful adherence of HIV-positives. Thus, acceptable and available combination prevention including a seek, test, treat, and retain approach for PWID will be necessary to control HIV and improve the health of this key population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

We thank the following deeply for their contributions and support: at NASCOP Dr. George Githuka, Eva Muluve, Mercy Nyakowa, Paul Macharia, Daniel Fedha; at the National HIV Reference Lab Joseph Ombayo, and the dedicated field staff; study Community Advisory Board members; at NYU David Resto; study consultants Scott Geibel, Steffanie Strathdee, Claris Ojwang, Elizabeth Ngugi, and Fred Owiti; and most of all the study participants. We are grateful to the NIH/NIDA for study funding (5R01DA032080, Kurth and Cherutich, principal investigators).

Source of Funding: The project described was supported by the Grant Number R01DA032080 from the National Institute on Drug Abuse (NIDA). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Drug Abuse or the National Institutes of Health (NIH).

REFERENCES

1. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012; 380(9859):2095–2128. [PubMed: 23245604]
2. Ortblad KF, Lozano R, Murray CJ. The burden of HIV: insights from the GBD 2010. Aids. 2013
3. Gelmon, L.; Kenya, P.; Oguya, F.; Cheluget, B.; Haile, G. Kenya HIV Prevention Response and Modes of Transmission Analysis. Nairobi, Kenya: Kenya National AIDS Control Council; 2009.
4. Vermund SH. Global HIV epidemiology: A guide for strategies in prevention and care. Current HIV/AIDS reports. 2014; 11(2):93–98. [PubMed: 24691698]
5. NASCOP. Unveiling new evidence for accelerated programming. Nairobi, Kenya: Ministry of Health; 2012. MARPS Surveillance Report 2012: Most-At-Risk Populations.
6. Asher AK, Hahn JA, Couture MC, Maher K, Page K. People who inject drugs, HIV risk, and HIV testing uptake in sub-Saharan Africa. The Journal of the Association of Nurses in AIDS Care : JANAC. 2013; 24(6):e35–e44. [PubMed: 23164598]
7. Petersen Z, Myers B, van Hout MC, Pluddemann A, Parry C. Availability of HIV prevention and treatment services for people who inject drugs: findings from 21 countries. Harm reduction journal. 2013; 10:13. [PubMed: 23957896]
8. Okal J, Geibel S, Muraguri N, et al. Estimates of the size of key populations at risk for HIV infection: men who have sex with men, female sex workers and injecting drug users in Nairobi, Kenya. Sexually transmitted infections. 2013; 89(5):366–371. [PubMed: 23761166]
9. NASCOP. National Data: Size Estimates by Typology. 2013 Available at http://nascop.or.ke/marps/national-data.php.
10. Beckerleg S, Telfer M, Hundt GL. The rise of injecting drug use in East Africa: a case study from Kenya. Harm reduction journal. 2005; 2:12. [PubMed: 16122382]
11. Beckerleg S, Telfer M, Sadiq A. A rapid assessment of heroin use in Mombasa, Kenya. Substance use & misuse. 2006; 41(6–7):1029–1044. [PubMed: 16809185]

12. McCurdy SA, Ross MW, Williams ML, Kilonzo GP, Leshabari MT. Flashblood: blood sharing among female injecting drug users in Tanzania. Addiction. 2010; 105(6):1062–1070. [PubMed: 20331567]
13. McNeil D. Desperate addicts inject each other's blood. The New York Times. 2010 Jul 12.
14. Mathers BM, Degenhardt L, Phillips B, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review. Lancet. 2008; 372(9651):1733–1745. [PubMed: 18817968]
15. Kenya NACCo. Kenya AIDS Response Progress Report: Progress towards Zero. 2014 Available at http://www.unaids.org/en/dataanalysis/knowyourresponse/countryprogressreports/2014countries/KEN_narrative_report_2014.pdf.
16. Cleland CM, Des Jarlais DC, Perlis TE, Stimson G, Poznyak V. Group WHOPIDICS. HIV risk behaviors among female IDUs in developing and transitional countries. BMC public health. 2007; 7:271. [PubMed: 17908299]
17. Jolley E, Rhodes T, Platt L, et al. HIV among people who inject drugs in Central and Eastern Europe and Central Asia: a systematic review with implications for policy. BMJ open. 2012; 2(5)
18. Jones A, Cremin I, Abdullah F, et al. Transformation of HIV from pandemic to low-endemic levels: a public health approach to combination prevention. Lancet. 2014; 384(9939):272–279. [PubMed: 24740087]
19. Mathers BM, Degenhardt L, Ali H, et al. HIV prevention, treatment, and care services for people who inject drugs: a systematic review of global, regional, and national coverage. Lancet. 2010; 375(9719):1014–1028. [PubMed: 20189638]
20. Smith DK, Martin M, Lansky A, Mermin J, Choopanya K. Update to Interim Guidance for Preexposure Prophylaxis (PrEP) for the Prevention of HIV Infection: PrEP for Injecting Drug Users. Morbidity and Mortality Weekly Report (MMWR). 2013; 62(23):463–465. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6223a2.htm. [PubMed: 23760186]
21. http://www.prepwatch.org/.
22. Wodak, A.; Cooney, A. Geneva, Switzerland: World Health Organization; 2004. Effectiveness of sterile needle and syringe programming in reducing HIV/AIDS among injecting drug users.
23. Des Jarlais DC, Feelemyer JP, Modi SN, Abdul-Quader A, Hagan H. High coverage needle/syringe programs for people who inject drugs in low and middle income countries: a systematic review. BMC public health. 2013; 13:53. [PubMed: 23332005]
24. Dutta A, Wirtz AL, Baral S, Beyrer C, Cleghorn FR. Key harm reduction interventions and their impact on the reduction of risky behavior and HIV incidence among people who inject drugs in low-income and middle-income countries. Current opinion in HIV and AIDS. 2012; 7(4):362–368. [PubMed: 22647588]
25. Degenhardt L, Mathers B, Vickerman P, Rhodes T, Latkin C, Hickman M. Prevention of HIV infection for people who inject drugs: why individual, structural, and combination approaches are needed. Lancet. 2010; 376(9737):285–301. [PubMed: 20650522]
26. Vlahov D, Junge B. The role of needle exchange programs in HIV prevention. Public health reports. 1998; 113(Suppl 1):75–80. [PubMed: 9722812]
27. Abdul-Quader AS, Feelemyer J, Modi S, et al. Effectiveness of structural-level needle/syringe programs to reduce HCV and HIV infection among people who inject drugs: a systematic review. AIDS and behavior. 2013; 17(9):2878–2892. [PubMed: 23975473]
28. Van Den Berg C, Smit C, Van Brussel G, Coutinho R, Prins M, Amsterdam C. Full participation in harm reduction programmes is associated with decreased risk for human immunodeficiency virus and hepatitis C virus: evidence from the Amsterdam Cohort Studies among drug users. Addiction. 2007; 102(9):1454–1462. [PubMed: 17697278]
29. Feelemyer J, Des Jarlais D, Arasteh K, Abdul-Quader AS, Hagan H. Retention of participants in medication-assisted programs in low- and middle-income countries: an international systematic review. Addiction. 2014; 109(1):20–32. [PubMed: 23859638]
30. Feelemyer JP, Des Jarlais DC, Arasteh K, Phillips BW, Hagan H. Changes in quality of life (WHOQOL-BREF) and addiction severity index (ASI) among participants in opioid substitution treatment (OST) in low and middle income countries: an international systematic review. Drug and alcohol dependence. 2014; 134:251–258. [PubMed: 24200104]

31. Volkow ND, Baler RD, Normand JL. The unrealized potential of addiction science in curbing the HIV epidemic. Current HIV research. 2011; 9(6):393–395. [PubMed: 21999774]
32. Heckathorn DD. Respondent driven sampling: a new approach to the study of hidden populations. Social Problems. 1997; 44:174–199.
33. Salganik MJ, Heckathorn DD. Sampling and estimation in hidden populations using respondent driven sampling. Sociological methodology. 2004; 34:193–239.
34. Heckathorn DD. Respondent driven sampling, II: deriving population estimates from chain-referral samples of hidden populations. Social Problems. 2002; 49(11–34)
35. Abdul-Quader AS, Heckathorn DD, McKnight C, et al. Effectiveness of respondent-driven sampling for recruiting drug users in New York City: findings from a pilot study. Journal of urban health : bulletin of the New York Academy of Medicine. 2006; 83(3):459–476. [PubMed: 16739048]
36. Magnani R, Sabin K, Saidel T, Heckathorn D. Review of sampling hard-to-reach and hidden populations for HIV surveillance. Aids. 2005; 19(Suppl 2):S67–S72. [PubMed: 15930843]
37. Handcock, MS.; Fellows, IE.; Gile, KJ. RDS: Respondent-Driven Sampling, Version 0.5. 2013. Project home page at http://hpmrg.org, URL http://CRAN.R-project.org/package=RDS
38. Team, RC. R Foundation for Statistical Computing. Vienna, Austria: 2014. R: A language and environment for statistical computing. URL http://www.R-project.org/.
39. Des Jarlais DC, Kling R, Hammett TM, et al. Reducing HIV infection among new injecting drug users in the China-Vietnam Cross Border Project. Aids. 2007; 21(Suppl 8):S109–S114. [PubMed: 18172378]
40. Uuskula A, Des Jarlais DC, Kals M, et al. Expanded syringe exchange programs and reduced HIV infection among new injection drug users in Tallinn, Estonia. BMC public health. 2011; 11:517. [PubMed: 21718469]
41. Jordan AE, Des Jarlais DC, Arasteh K, McKnight C, Nash D, Perlman DC. Incidence and prevalence of hepatitis c virus infection among persons who inject drugs in New York City: 2006–2013. Drug and alcohol dependence. 2015
42. Kimanga DO, Ogola S, Umuro M, et al. Prevalence and incidence of HIV infection, trends, and risk factors among persons aged 15–64 years in Kenya: results from a nationally representative study. Journal of acquired immune deficiency syndromes. 2014; 66(Suppl 1):S13–S26. [PubMed: 24445338]
43. McMahon JH, Elliott JH, Bertagnolio S, Kubiak R, Jordan MR. Viral suppression after 12 months of antiretroviral therapy in low- and middle-income countries: a systematic review. Bulletin of the World Health Organization. 2013; 91(5):377–385E. [PubMed: 23678201]
44. McClelland RS, Richardson BA, Wanje GH, et al. Association between participant self-report and biological outcomes used to measure sexual risk behavior in human immunodeficiency virus-1-seropositive female sex workers in Mombasa, Kenya. Sexually transmitted diseases. 2011; 38(5): 429–433. [PubMed: 21217420]
45. Strathdee SA, Hallett TB, Bobrova N, et al. HIV and risk environment for injecting drug users: the past, present, and future. Lancet. 2010; 376(9737):268–284. [PubMed: 20650523]
46. MoH. Kenya HIV Prevention Revolution Road Map: Count Down to 2030. 2014. Available at http://hivhealthclearinghouse.unesco.org/sites/default/files/resources/kenya_hiv_prevention_revolution_road_map.pdf.

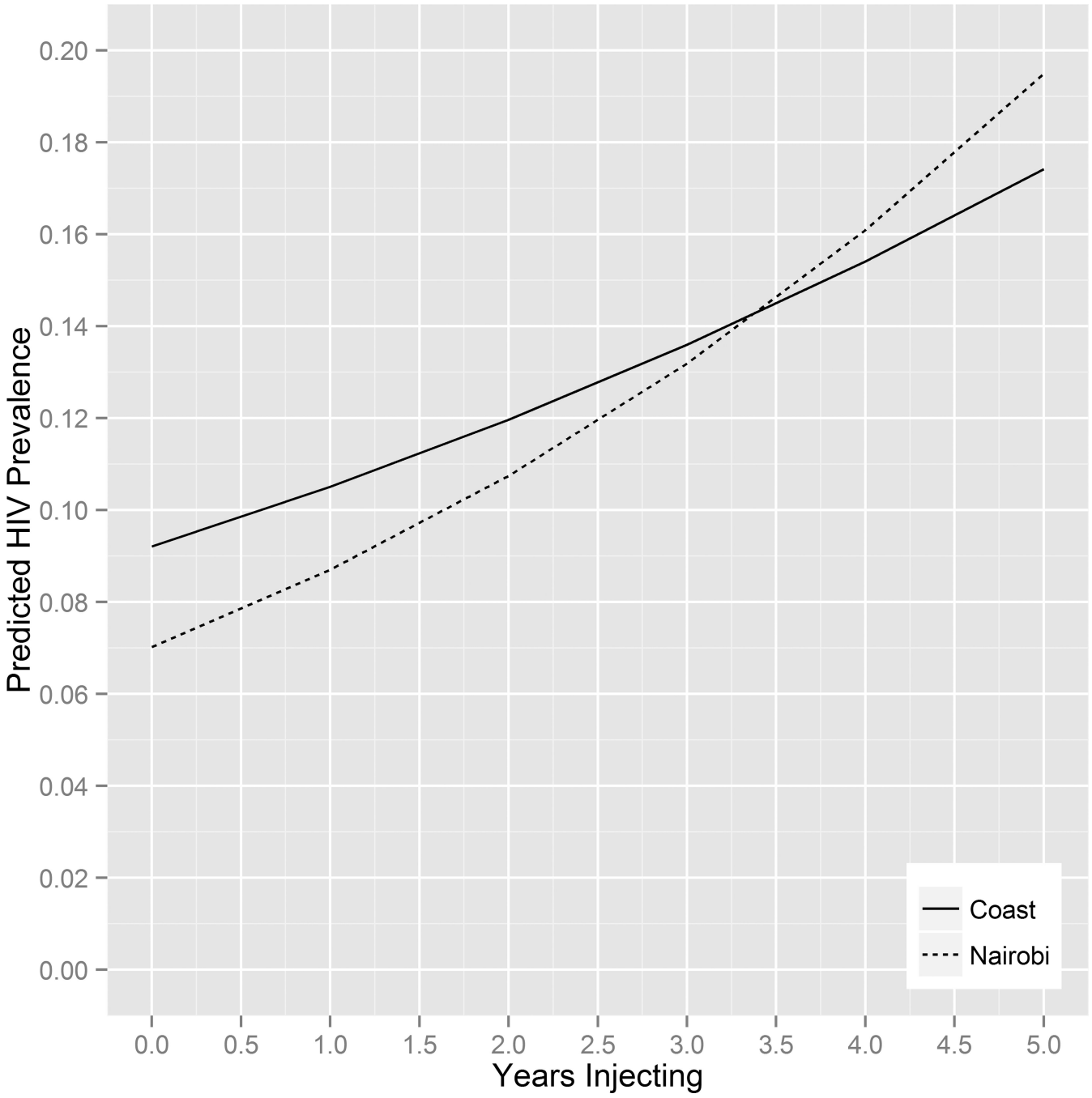

Figure 1.
Predicted HIV prevalence in each region by years of injecting

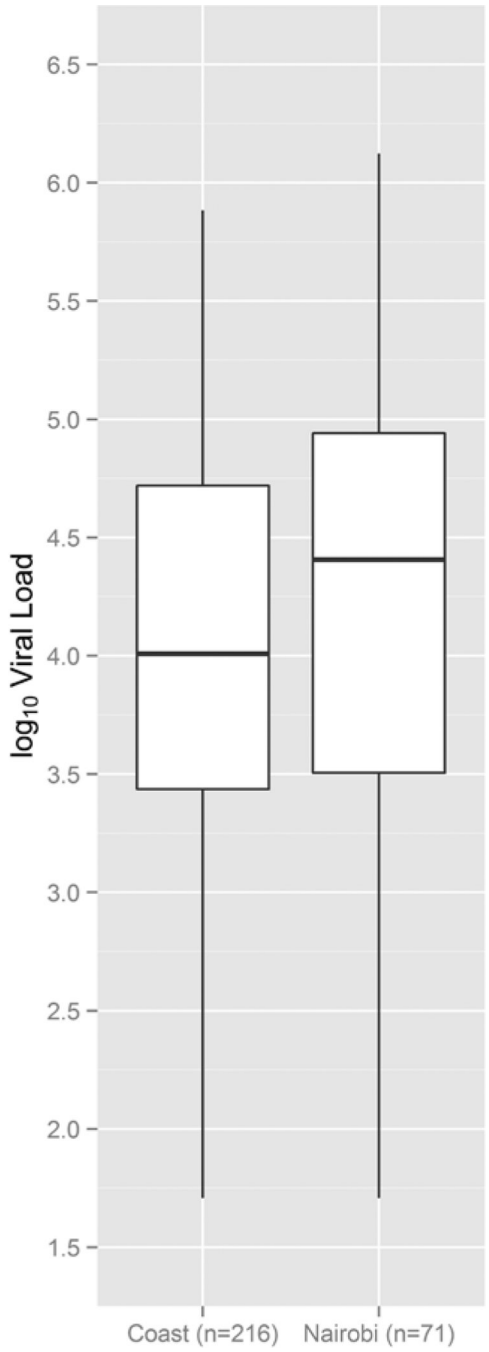

Figure 2.
Distributions of $\log_{10}$ HIV viral load among participants with newly diagnosed and previously diagnosed HIV infection in Nairobi and Coast Region

TABLE 1

Characteristics of people who inject drugs in Kenya

	Coast (n=1122)	Nairobi (n=663)
Age (years)	31.71 (6.50)	30.40 (7.00)
Gender Male (%)	89.0 [86.5–91.4]	82.4 [75.1–89.7]
PWID Social Network Size (n)	22.47 (33.39)	18.67 (47.05)
Age at First Injection (years)	25.80 (6.33)	25.92 (7.01)
Years Injecting (mean, SD)	5.91 (5.67)	4.49 (4.89)
Number of Injections Past Month (mean, SD)	68.15 (34.73)	69.33 (30.18)
Days Injecting Past Month (mean, SD)	25.89 (9.31)	28.04 (6.60)
Average Injections/Day (SD)	2.87 (3.67)	2.57 (1.50)
Receptive Needle Sharing at Last Injection (%)	4.2 [2.7–5.7]	23.4 [18.7–28.1]
Receptive Sharing of Cookers/Cotton/Water/Bleach, Last Injection (%)	17.1 [14.1–20.1]	73.5 [68.8–78.2]
Age at Sexual Debut (years)	16.72 (3.47)	16.37 (3.44)
No Condom with Main Partner at Last Sex (%)	23.7 [20.7–26.7]	18.3 [14.2–22.5]
No Condom with Casual Partner at Last Sex (%)	6.2 [4.5–7.8]	5.0 [2.9–7.2]
HIV Infection (%, CI)	20.5 [17.3–23.6]	14.5 [10.8–18.2]
Previously Diagnosed	14.5 [11.9–17.2]	8.2 [5.6–10.8]
Newly Diagnosed	5.9 [4.1–7.8]	6.3 [3.8–8.8]

Cell contents are mean (SD) or RDS weighted estimate of percentage [percentile bootstrap 95% confidence interval]

TABLE 2

Correlates of HIV infection

	Coast (n=1122)		Nairobi (n=663)	
	Odds Ratio	**95% CI**	**Odds Ratio**	**95% CI**
Age	1.38	1.19–1.59	1.10	0.90–1.34
Gender Male	0.19	0.13–0.28	0.44	0.28–0.72
PWID Social Network Size†	1.10	0.95–1.26	1.30	1.07–1.58
Age at First Injection†	0.72	0.61–0.84	0.74	0.59–0.91
Years Injecting†	1.89	1.65–2.18	1.55	1.30–1.85
Number of Injections per month†	1.38	1.19–1.61	1.18	0.96–1.44
Days Injecting per month†	1.26	1.07–1.51	0.98	0.81–1.21
Average Injections/Day †	1.22	1.05–1.59	1.35	1.09–1.74
Receptive Needle Sharing at Last Injection	3.74	2.07–6.73	1.96	1.24–3.05
Receptive Sharing of Cookers/Cotton/Water/Bleach at Last Injection	1.52	1.10–2.10	0.79	0.52–1.21
Age at Sexual Debut†	1.16	1.01–1.34	1.03	0.84–1.26
No Condom with Main Partner at Last Sex	0.76	0.53–1.09	0.98	0.56–1.63
No Condom with Casual Partner at Last Sex	0.81	0.41–1.49	1.48	0.61–3.20

† These variables were rescaled to estimate the change in odds of infection associated with a one standard deviation change in the predictor.

TABLE 3

Predictors of HIV infection in Multivariable Logistic Regression

	Coast (n=1122)		Nairobi (n=663)	
	Odds Ratio	**95% CI**	**Odds Ratio**	**95% CI**
Gender Male	0.15	0.10–0.22	0.38	0.24–0.63
Years Injecting†	2.00	1.73–2.33	1.62	1.35–1.95
Number of Injections per month†	1.26	1.07–1.48	--	--
Receptive Needle Sharing at Last Injection	3.33	1.74–6.37	2.05	1.28–3.26

†These variables were rescaled to estimate the change in odds of infection associated with a one standard deviation change in the predictor.