

**UNDERSTANDING THE IMPACT OF MULTIPLE FORMS OF VIOLENCE ON
SEXUAL AND DRUG-RELATED HIV RISK IN FEMALE SEX WORKERS**

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Dissertation Abstract

Background: Female sex workers (FSW) are a key population in the HIV epidemic and in many settings face high levels of violence from intimate partners, clients, police, and pimps. FSW are therefore at risk of polyvictimization, or experiencing multiple types of violence.

Methods: Using respondent-driven sampling, 754 FSW from Russia were recruited. Participants self-reported lifetime exposure to client, police, intimate partner, and pimp violence, as well as recent injecting drug use, inconsistent condom use with intimate partners, and inconsistent condom use with clients.

Results: Lifetime violence was prevalent, with 44.8% experiencing any violence, including 31.7% from clients, 16.0% from police, 15.7% from intimate partners, and 11.4% from pimps. One-fifth (20.4%) experienced polyvictimization. Client violence was one of the strongest independent correlates of the other three types of violence.

Respondents reported prevalent recent injecting drug use (10.7%), inconsistent condom use with intimate partners (45.1%), and inconsistent condom use with clients (22.5%). Intimate partner violence was associated with all three risk behaviors, police violence was associated with both sexual risk outcomes, and client violence was associated with injecting drug use, while pimp violence was not associated with any of the three risk behaviors.

Linear dose-response analyses standard to syndemics research demonstrated that the risk of injecting drug use (ARR=1.37, 95% CI 1.04, 1.81), inconsistent condom use with intimate partners (ARR=1.04, 95% CI 1.01, 1.08), and inconsistent condom use with clients (ARR=1.27, 95% CI 1.07, 1.49) rises as the number of types of violence experienced increases. We propose three novel analyses to measure whether these four types of violence synergistically increase HIV risk; none demonstrated synergism.

Conclusions: The present study is unique for measuring four major types of violence against FSW and three major HIV risk pathways. All three pathways were associated with multiple types of violence; these results support the World Health Organization mandate that violence prevention needs to be integrated into HIV prevention programming for FSW, and demonstrates the importance of considering multiple forms of violence and of considering different types of violence for each specific HIV risk pathway. The novel synergism analyses proposed can be leveraged to advance syndemics research.

Introduction and specific aims

Female sex workers (FSW) globally have been and continue to be a key population in the HIV epidemic, with indications that the number of women involved in the sex trade is only growing.[1] A systematic review of studies from 50 countries found that FSW have an average HIV prevalence of 11.8% and have 13.5 times higher odds of HIV infection than the overall population of adult women.[2] FSW also shoulder a high burden of substance use[3] and physical and sexual violence victimization.[4] As in the general population,[5-7] increasing evidence links violence against FSW with substance abuse,[8-11] sexual risk behavior,[12] and HIV infection.[10, 13-15]

The term *syndemic* emerged in 1996 to reflect substance abuse, violence, and AIDS (SAVA) as 1) mutually reinforcing and enhancing, 2) synergistically producing excess burden of disease on the population, and 3) influenced by structural violence and inequality.[16] In a recent review of quantitative evidence for the SAVA syndemic among US women, only one of 45 articles focused specifically on FSW,[5] even though FSW report high levels of HIV, substance use, and physical and sexual violence from clients, police, and intimate partners worldwide.[4] Further, these distinct types of violence have different impacts on health,[17] yet most SAVA analyses either focus on a single type of violence or use global measures of violence that make no distinction between specific types or perpetrators of violence. A parallel field of polyvictimization research focuses on multiple types of violence, primarily during childhood. The ground-breaking Adverse Childhood Experiences (ACE) study used a dose-response

framework to show that as the number of ACEs accumulated, the risk of health problems in adulthood dramatically increased.[18] The syndemic effects of polyvictimization in adulthood and in sex work contexts have not been well characterized.

The thesis research extends polyvictimization and syndemic frameworks by creating a FSW-specific syndemic or polyvictimization model focused on violence. This model evaluates multiple forms of violence as distinct exposures and quantitatively investigates the synergistic impact of different forms of violence on health. Cross-sectional analyses of a survey collected in 2011 from three sites in Russia (n=754 FSW)[14] evaluate an extended model by assessing the independent and interactive influence of violence from four different types of perpetrators (intimate partners, clients, pimps, and police) on sexual and drug-related HIV risk. Russia is a compelling setting in which to study the nexus of HIV, substance use, and violence in sex work as it transitions toward a heterosexual contact-driven HIV epidemic from an injecting drug use-driven epidemic,[19] and it is one of the only regions of the world where HIV prevalence and incidence are still increasing.[20, 21]

This dissertation research provides a basis for understanding the nature and extent of polyvictimization in propagating HIV and substance use risk in the context of sex work. Methodologically, it extends the linear dose-response techniques frequently used to assess syndemics and polyvictimization[18, 22-25] by using interaction terms to understand the synergistic effects of violence on health. Intimate partners, clients, pimps, and police are the most common violence perpetrators among FSW,[4] yet few studies assess all four or have sufficient sample size to explore interaction effects. Despite World Health Organization calls for violence interventions as a critical component of HIV prevention,[26, 27] violence has not been consistently or comprehensively integrated into HIV and substance abuse research. This study informs assessment of and intervention on distinct forms of violence in research and service provision for FSW, lays the foundation for understanding polyvictimization in sex work contexts, and advances quantitative methods associated with syndemic theory and polyvictimization research.

Aim 1:

Aim 1.1: Quantify the prevalence of and the relationship between specific types of violence (violence from intimate partners, clients, pimps, and police) among a sample of Russian FSW.

Aim 1.2: Identify and describe polyvictimization clusters, and identify key covariates associated with membership in specific polyvictimization clusters.

Aim 2: Quantify the individual association between each type of violence and the dominant forms of sexual and drug-related HIV risk (injecting drug use, inconsistent condom use with clients, and inconsistent condom use with intimate partners).

Aim 3: Using dose-response and interaction analyses, evaluate the extent of a synergistic relationship between multiple types of violence on sexual and drug-related HIV risk among FSW.

References

1. Ward H, Aral S. Globalisation, the sex industry, and health. *Sexually transmitted infections*. 2006;82(5):345-7.
2. Baral S, Beyrer C, Muessig K, Poteat T, Wirtz AL, Decker MR, et al. Burden of HIV among female sex workers in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet infectious diseases*. 2012;12(7):538-49.
3. Rekart ML. Sex-work harm reduction. *The Lancet*. 2006;366(9503):2123-34.
4. Decker MR, Crago A-L, Chu SK, Sherman SG, Seshu MS, Buthelezi K, et al. Human rights violations against sex workers: burden and effect on HIV. *The Lancet*. 2014.
5. Meyer JP, Springer SA, Altice FL. Substance abuse, violence, and HIV in women: a literature review of the syndemic. *Journal of Women's Health*. 2011;20(7):991-1006.
6. Campbell JC, Baty M, Ghandour RM, Stockman JK, Francisco L, Wagman J. The intersection of intimate partner violence against women and HIV/AIDS: a review. *International journal of injury control and safety promotion*. 2008;15(4):221-31.
7. Gielen AC, Ghandour RM, Burke JG, Mahoney P, McDonnell KA, O'Campo P. HIV/AIDS and Intimate Partner Violence Intersecting Women's Health Issues in the United States. *Trauma, Violence, & Abuse*. 2007;8(2):178-98.
8. Chersich M, Luchters S, Malonza I, Mwarogo P, King'Ola N, Temmerman M. Heavy episodic drinking among Kenyan female sex workers is associated with unsafe sex, sexual violence and sexually transmitted infections. *International journal of STD & AIDS*. 2007;18(11):764-9.

9. Odínokova V, Rusakova M, Urada LA, Silverman JG, Raj A. Police sexual coercion and its association with risky sex work and substance use behaviors among female sex workers in St. Petersburg and Orenburg, Russia. *International Journal of Drug Policy*. 2014;25(1):96-104.
10. Ulibarri MD, Strathdee SA, Ulloa EC, Lozada R, Fraga MA, Magis-Rodríguez C, et al. Injection drug use as a mediator between client-perpetrated abuse and HIV status among female sex workers in two Mexico-US border cities. *AIDS and Behavior*. 2011;15(1):179-85.
11. Decker MR, Wirtz AL, Baral SD, Peryshkina A, Mogilnyi V, Weber RA, et al. Injection drug use, sexual risk, violence and STI/HIV among Moscow female sex workers. *Sexually transmitted infections*. 2012;88(4):278-83.
12. Argento E, Muldoon KA, Duff P, Simo A, Deering KN, Shannon K. High prevalence and partner correlates of physical and sexual violence by intimate partners among street and off-street sex workers. *PloS one*. 2014;9(7):e102129.
13. Braunstein SL, Ingabire CM, Geubbels E, Vyankandondera J, Umulisa M-M, Gahiro E, et al. High burden of prevalent and recently acquired HIV among female sex workers and female HIV voluntary testing center clients in Kigali, Rwanda. *PloS one*. 2011;6(9):e24321.
14. Decker MR, Wirtz AL, Moguilnyi V, Peryshkina A, Ostrovskaya M, Nikita M, et al. Female sex workers in three cities in Russia: HIV prevalence, risk factors and experience with targeted HIV prevention. *AIDS and behavior*. 2014;18(3):562-72.
15. Jewkes RK, Dunkle K, Nduna M, Shai N. Intimate partner violence, relationship power inequity, and incidence of HIV infection in young women in South Africa: a cohort study. *The Lancet*. 2010;376(9734):41-8.
16. Singer M. A dose of drugs, a touch of violence, a case of AIDS: conceptualizing the SAVA syndemic. *Free Inquiry in Creative Sociology*. 1996;24(2):99-110.
17. Decker MR, Pearson E, Illangasekare SL, Clark E, Sherman SG. Violence against women in sex work and HIV risk implications differ qualitatively by perpetrator. *BMC public health*. 2013;13(1):876.
18. Felitti M, Vincent J, Anda M, Robert F, Nordenberg M, Williamson M, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American journal of preventive medicine*. 1998;14(4):245-58.
19. UNAIDS. Country Progress Report of the Russian Federation on the Implementation of the Declaration of Commitment on HIV/AIDS. Moscow: 2008.
20. USAID. HIV/AIDS Health Profile: Europe and Eurasia Region. 2012.
21. Pokrovskiy V, Ladnaya N, Tushina O, Buravtsova E. HIV-Infection. Informational Bulletin #40 (ВИЧ-Инфекция. Информационный бюллетень №40). Moscow: Federal Scientific and Methodological Center for AIDS Prevention and Control (Федеральный научно-методический центр по профилактике и борьбе со СПИДом), 2015.
22. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *American journal of public health*. 2003;93(6):939-42.
23. Parsons JT, Grov C, Golub SA. Sexual compulsivity, co-occurring psychosocial health problems, and HIV risk among gay and bisexual men: further evidence of a syndemic. *American Journal of Public Health*. 2012;102(1):156-62.
24. Egan JE, Frye V, Kurtz SP, Latkin C, Chen M, Tobin K, et al. Migration, neighborhoods, and networks: approaches to understanding how urban environmental conditions affect syndemic adverse health outcomes among gay, bisexual and other men who have sex with men. *AIDS and Behavior*. 2011;15(1):35-50.
25. Brennan J, Kuhns LM, Johnson AK, Belzer M, Wilson EC, Garofalo R. Syndemic theory and HIV-related risk among young transgender women: the role of multiple, co-occurring health problems and social marginalization. *American journal of public health*. 2012;102(9):1751-7.
26. World Health Organization UNPF, Joint United Nations Programme on HIV/AIDS, Global Network, of Sex Work Projects TWB. Implementing comprehensive HIV/STI programmes with sex

workers: practical approaches from collaborative interventions. Geneva: World Health Organization, 2013.

27. World Health Organization. Violence against sex workers and HIV prevention. Geneva: WHO, 2005.

Dissertation organization

Chapter 1 introduces the aims of the dissertation and provides the background literature review to frame the work.

Chapter 2 is the methodology chapter. It provides detailed methods from the parent study and then delves into details from this analysis, including handling of missing data, development and definition of exposure and outcome variables, and description and justification of methods chosen.

Chapter 3 is the first manuscript. Focusing on the four primary violence exposures, it explores the associations between specific types of violence and describes how violence types are distributed throughout the population. It also identifies clusters of FSW based on their violence victimization profiles and identifies demographic predictors of violence cluster membership.

Chapter 4 is the second manuscript. This chapter introduces the three HIV risk outcomes and examines how each type of violence is related to each HIV risk outcome, sketching an initial picture of how specific types of violence are more strongly implicated in some HIV risk pathways than in others.

Chapter 5 is the third manuscript. This chapter explores whether these four types of violence constitute a syndemic that synergistically drives HIV risk outcomes, both using standard dose-response analyses from the field of syndemics and also proposing three new analytic plans that are better able to measure synergism between syndemic factors. We compare findings from both the standard and the proposed analytic strategies in light of the theoretical literature in the field, and make suggestions for improving the standard analytic tools of the field.

Chapter 6 is a concluding chapter that discusses the three manuscripts together. It summarizes the findings, suggests future research directions, and outlines the strengths, limitations, and implications for programming, policy, and research.

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1. Background and significance

HIV, sexual risk, and substance abuse among sex workers

More than 30 years into the HIV epidemic, in 2016 there were still 1.8 million incident infections and 1 million AIDS-related deaths globally.[1] Female sex workers (FSW) have been and continue to be a key population in the HIV epidemic, with indications that the sex trade is growing globally.[2] A systematic review of studies from 50 countries found that FSW have an average HIV prevalence of 11.8% and have 13.5 times higher odds of HIV infection than the overall population of adult women.[3]

The primary proximal causes of HIV infection among FSW are sexual risk from clients, sexual risk from non-clients, and injecting drug use. The average HIV transmission efficiency of unprotected receptive vaginal sex is roughly 0.11% per act[4] and the transmission efficiency of unprotected receptive anal sex is roughly 1.4% per act.[5] Sexual risk for FSW varies by the type of sex work, though sex work broadly involves a high number of partners with high concurrency, placing FSW at risk of HIV.[3] Condom usage with clients is one of the UNAIDS core indicators.[6] Unprotected sex with intimate partners is an important, yet understudied, source of HIV risk given higher frequency of unprotected sex with intimate partners as compared to clients [7-9] and the association of having an intimate partner with HIV risk for FSW.[7, 10, 11] Both clients and partners of FSW are often higher-risk partners than the general population of men, i.e. more likely to be living with HIV and engaging in HIV risk behaviors, which places FSW at greater risk of acquiring the virus.[12, 13]

There are a range of factors that influence condom use with clients and non-paying partners. Using the framework of the Modified Social Ecological Model for HIV epidemics,[14] there are factors at the level of the individual, social and sexual network, community, policy, and HIV epidemic stage. At the policy level, the Russian government does not fund FSW-specific HIV prevention programming or conduct HIV surveillance specific to this population.[15, 16] This translates to a lack of prevention resources at the community level, making condoms more scarce or less accessible. Having condoms freely available, rather than having to purchase them, also promotes condom use among FSW.[17]

Options such as the availability of female condoms and lubricant also increases condom usage among FSW.[18] Sex work venue can impact condom use depending on whether pimps or brothel owners support the use of condoms. For instance, after the Thai 100% condom campaign started sanctioning brothel owners if FSW did not use condoms, condom use rose from 14% to 94%, at least initially.[19] At the level of the individual, FSW may not be exposed to prevention education outreach and therefore may not fully understand the risks of non-condom use or how to protect oneself from HIV. Clients may offer FSW more money to have sex without a condom, and FSW experiencing unmet economic needs may feel incentivized to accept non-condom use.[20, 21] FSW who use drugs may be more likely to engage in non-condom use, either due to impaired judgment or financial need borne of drug use.[22] Individuals' perceptions of how prevalent HIV is in their community, as well as how prevalent HIV actually is in their community, also influence their decisions around condom use.[23] FSW who have high self-efficacy for negotiating and using condoms with clients or intimate partners are also more able to do so.[24] At the sexual network and partner level, FSW may be influenced by how normative condom use is among their sexual partners. In many settings, FSW rarely use condoms with intimate partners because norms around condom use state that condom use is indicative of a lack of trust and intimacy in the relationship.[25] Gender norms in many settings also dictate that men have the ability to decide the terms of sexual encounters, including condom use.[26] If the partner does not know about their sex work, FSW may fear that insisting on using a condom will reveal that they are sex workers.[27] Violence from clients, pimps, police, and intimate partners can also constrain choices around condom use (see Mechanisms linking violence to sexual risk and substance use outcomes, below).

In many areas of the world, there is a strong overlap between sex workers and people who inject drugs, as sex workers may initiate drug use to cope with trauma or job-related stress, and drug users may initiate sex work to help pay for drugs.[21] The HIV transmission efficiency of needle sharing is estimated to be between 0.63% and 2.4% per act.[28] People who inject drugs are also a key population in the HIV epidemic, with an estimated 13% HIV prevalence globally in this population.[29] Data suggest that women who inject drugs may be more likely to be living with HIV than men who inject drugs,

pointing to gendered vulnerabilities to HIV and also to the large overlap with sex work populations.[22] FSW who inject drugs have higher levels of sexual HIV risk than their non-injecting counterparts in addition to their drug-related risk.[30, 31] In many global settings, FSWs have high prevalence of injection drug use[32-36] and FSWs who inject drugs are at heightened HIV risk.[12, 37-39]

Many factors affect injection drug use in sex workers. Geographically, Russia's proximity to heroin-producing Afghanistan via porous former Soviet states ensures widespread access to the drug.[40] Sex workers specifically often take up or intensify their drug use to cope with the stress or trauma of selling sex.[41] They may also use stimulants to stay awake at night in order to work.[42] At the level of social or sexual networks, FSW may be introduced to drugs by pimps, clients, or intimate partners.[41, 43, 44] Because sex work and drug use are both criminalized in many countries, FSW may encounter high levels of drug use in prison and begin or intensify drug use there.[45] Violence from clients, police, intimate partners, and pimps can also constrain choices around injecting and safe injecting (see Mechanisms linking violence to sexual risk and substance use outcomes, below). Sex work type or venue may influence access to and norms around drug use, including clientele who insist on drug use with sex workers as part of the sexual service.[46] At a policy level, the Russian government has banned the provision of opioid substitution therapy (OST),[15] which is the evidence-based treatment for opioid dependence and has been shown to reduce injecting, unsafe injecting, unsafe sex, and HIV incidence among drug users.[47] As a result, users find it more challenging to quit than in settings where OST is available. Sex workers in some settings may also be banned from accessing treatment services unless they stop selling sex; access to domestic violence shelters or other services that might be able to provide referrals and support for treatment are also often closed to FSW.[46] In Russia, needle and syringe exchange programs operate in a legal grey area and are not funded by the national government;[15] as such, their coverage is poor. This limits access to HIV prevention tools and education and reduces the opportunities to receive referrals for drug treatment or other programs that would reduce injecting drug use.

HIV risk and violence among FSW

As described by frameworks such as the HIV Risk Environment approach[48, 49] and the Modified Social Ecological Model for HIV epidemics,[14] structural factors exogenous to the individual such as the legal environment around sex work and drug use, poverty, gender inequality, and exclusion from HIV prevention services can make it more difficult for FSW to access clean injecting equipment, access condoms, and successfully negotiate condom use.[3, 21, 50, 51] One such factor driving HIV risk among FSW is violence. As in the general population,[52-54] increasing evidence links violence against FSW with substance abuse,[55-58] sexual risk behavior,[59, 60] and HIV infection.[57, 61] Early HIV prevention interventions focused on individual-level factors, such as promotion of condom use, needle exchange programs, and HIV testing. More recently, violence and coercion are emerging as key structural features in the broader living and working risk environments of FSW and people who inject drugs.[20, 48] Violence is a structural driver of HIV that impinges upon the ability to practice safer sex[20] and may lead to injecting drug use[57] as a coping mechanism for trauma.

Sex workers face unique forms of violence, each of which has different HIV risk implications. Women globally are most at risk of physical and sexual violence from intimate partners,[62] but FSWs face violence not just from intimate partners[10, 60, 63-68] but additionally from clients,[41, 44, 57, 58, 63, 66, 69-72] pimps,[41, 73] and police[44, 58, 63, 69, 70, 74, 75] as a result of their occupation. Violence from each of these sources is qualitatively different in intensity, context, risk factors, and implications for HIV. Sexual violence from *clients* often involves pressure to perform higher-risk sexual acts, such as anal or unprotected sex, or sex with multiple clients at the same time.[73, 76, 77] *Intimate partners* may initiate violence to punish the FSW for engaging in sex work or to push women to sell riskier sex to make more money or obtain drugs.[59, 76] Women may also engage in riskier sex work to become financially independent from abusive partners.[68] *Pimps* may use physical and sexual violence or promote drug addiction[44] to ensure compliance with riskier sex acts or higher client volume than the sex worker would otherwise choose.[73, 76] *Police violence* is linked to HIV risk via a variety of routes,

including direct exposure to unprotected sexual violence from police themselves and harassment and seizure of condoms or syringes as evidence of selling sex.[70] Additionally, police harassment pushes sex workers more underground where they may be forced to take riskier or more violent clients,[59, 70, 77] and arrest places FSW in high-risk detention centers where needle sharing, as well as further violence, are common.[50, 78, 79] Violence from each of these sources is qualitatively different in intensity, chronicity, context, risk factors, and implications for HIV and substance use.

We define violence types by perpetrator rather than classifying as physical, sexual, or psychological because disaggregating violence by perpetrator type is critical for designing violence and HIV prevention interventions. Violence from one type of perpetrator requires different interventions than violence from another type of perpetrator. For example, interventions to reduce client violence may include structural changes to sex work venues such as requiring client sign-in, emergency call buttons, and supportive managerial policies and crisis response,[80] while interventions to reduce police violence may involve training police, policy advocacy to change laws allowing condoms as evidence of sex work, and facilitating sex worker-police partnerships.[81, 82] This focus on perpetrator-specific violence and interventions matches an overall shift in the violence research field to broaden its focus from interventions that provide services to survivors of violence to primary prevention of violence.[83] Recent evidence from a systematic review has shown that interventions that attempt to protect potential victims from abuse have limited success at reducing victimization, and that primary prevention interventions should focus on potential perpetrators.[83]

Despite the differing implications for interventions and HIV, many studies of violence against FSW do not distinguish between perpetrators or only measure violence by one type of perpetrator.[57, 84-87] Measuring only one form of violence has limited our understanding of synergistic effects of specific combinations; for instance, client violence may have a stronger effect on HIV risk if FSW are also experiencing police violence and have no recourse to police. A 2008 systematic review of HIV interventions for sex workers found some evidence that multipronged structural approaches that promote

sex worker's rights reduce HIV risk,[88] and since then additional intervention evaluations among FSW have supported this.[81] However, it remains unclear what forms of violence are most important to target in interventions and how to best address multiple co-occurring forms of violence in the context of sex work. The dissertation research is significant in advancing our understanding of how specific types of violence perpetrated by multiple perpetrators in sex work contexts can interact to produce excess HIV risk beyond that of cumulative exposure to victimization in general.

Mechanisms linking violence to sexual risk and substance use outcomes

The effect of violence of any type on HIV risk

The focus of the dissertation is in understanding how specific forms of violence increase HIV risk, and we state below why we hypothesize that each form of violence has a distinct effect on and pathway to HIV risk. However, in addition to the pathways by which specific forms of violence lead to each outcome, there are psychosocial mediators between violence and HIV risk that are shared across the different types of violence (Figure 1). We describe these mediators here to present a more complete understanding of the relationship between violence and HIV, even though the analytic plan does not include an exploration of these psychosocial mediators or path analysis.

In responding to violence and trauma, psychological outcomes that mediate sexual or drug-related HIV risk can be triggered, including depression, PTSD, and chronic stress responses.[89, 90] An individual may also use non-injecting drugs, such as alcohol, to cope with the effects of trauma. All of these trauma responses can increase the likelihood of both non-condom use and injecting drug use.[89, 90] Experiencing trauma can also reduce self-efficacy, which may reduce women's capacity for negotiating condom use and using condoms with clients or intimate partners.[91, 92] Sexual violence particularly has been noted to alter sexual behavior, including predisposing the survivor to either hyperarousal or sex avoidance, which affects the likelihood of their exposure to unprotected sex.[89, 90]

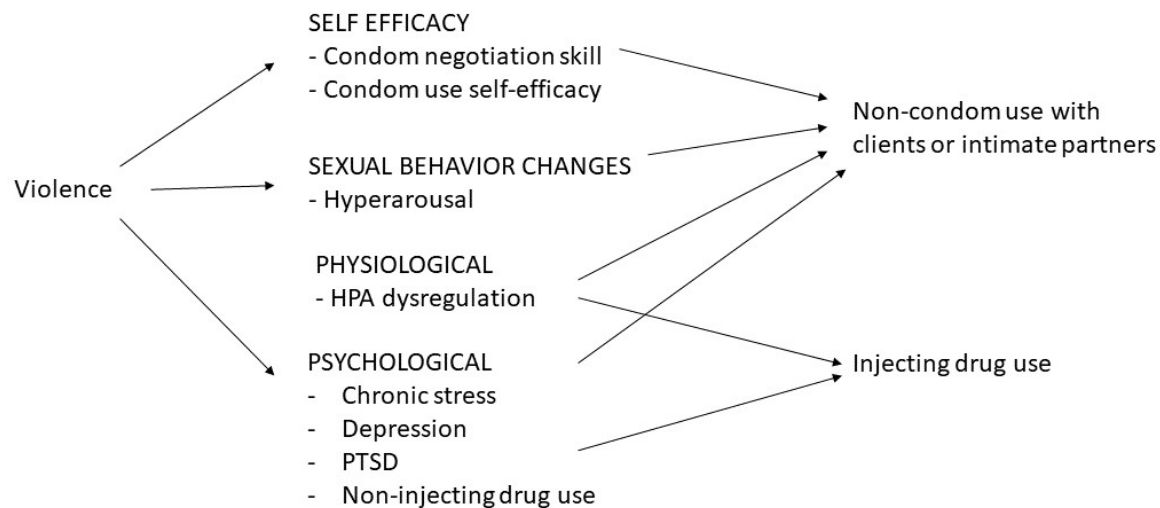


Figure 1.1: Psychosocial mediators between violence and sexual and drug-related HIV risk outcomes.

While characteristics related to self-efficacy, sexual behavior, and psychological responses to trauma are potential mediators of our outcomes, we do not investigate them in the analysis. The focus of the analysis is to understand how *specific* forms of violence interact with one another to produce HIV risk, rather than focusing on understanding mediation pathways between any violence generally and HIV risk. The survey did not include validated scales for many of the plausible mediators, such as PTSD and depression, and so is not well suited for a mediation analysis. However, these pathways are reviewed here as they may aid in interpreting findings and suggesting future avenues of research and intervention, including mediation analysis and secondary prevention interventions that treat the psychosocial mediators.

Condom use with clients

Client violence is often directly linked to non-condom use with clients, with clients directly enforcing non-condom use through violence, or FSW not using condoms out of fear of violence.[73, 76, 77] Intimate partners may use violence to push women to sell riskier sex to make more money.[59, 76] Further, women may engage in riskier, unprotected sex work to become financially independent from

abusive partners.[68] Police violence is linked to inconsistent condom use with clients, as carrying condoms can be used as evidence of engaging in sex work in many settings, leading FSW to choose not to keep condoms available or leading to police seizing condoms as evidence.[70] Police violence and harassment can also push sex workers more underground, where they may be forced to take riskier or more violent clients who may be less likely to use condoms.[59, 70, 77] Pimp violence has been associated with condom non-use with clients;[93] pimps may use violence to ensure FSW comply with demands for riskier, more highly paid sex acts such as unprotected vaginal or anal sex.[58]

Condom use with non-paying partners

Research focusing on condom use with non-paying partners among FSW has lagged behind research on FSWs' other sources of sexual and drug-related HIV risk, namely inconsistent condom use with clients and injecting drug use. The lack of attention to intimate partners in HIV research is in part due to persistent myths that FSW do not have intimate partners.[94] Literature linking violence from intimate partners and inconsistent condom use with those partners is most robust due to the direct link, and comes from women in the general population as well as FSW.[10, 95-97] Client violence has also been linked to inconsistent condom use with non-paying partners.[25, 97] In some settings, client violence is more strongly associated with condom use in non-paying relationships than it is with condom use in paying relationships.[25] This is partially because in many settings, virtually all FSW report non-negotiable consistent condom use with clients, while consistent condom use with non-paying partners tends to be much less prevalent and therefore potentially more dependent on other factors.[25] Client violence may be associated with inconsistent condom use with intimate partners due to the non-specific trauma pathways described above, e.g. reducing self-efficacy. However, the extent to which apparent associations between client violence and inconsistent condom use with intimate partners is an artifact of sex workers considering regular clients to be intimate partners is unclear.[25] Less still is known about the links between pimp or police violence and condom use with non-paying partners.

Injecting drug use

In longitudinal studies, there is a bidirectional link between IPV and injecting drug use, with drug use increasing women's vulnerability to violence and violence increasing women's use of drugs.[98] In many settings, injecting drug use and sex work are both illegal, and women who both sell sex and use drugs are further marginalized, socially isolated, and made vulnerable to work-related violence,[80] including police violence.[99] Arrest by police and placement in high-risk detention centers can expose FSW to a concentrated population of other women who use drugs and engage in needle sharing, increasing their likelihood of injecting and unsafe injection.[50, 78, 79] Client violence has been associated with injecting drug use as a coping mechanism for trauma.[57] Pimps may also use violence to initiate or promote drug addiction among FSW[44] in order to increase their dependency. Pimp violence has also been associated with non-injecting drug use.[100] In return, drug use can increase the likelihood of violence by disrupting cognition and impairing judgment, potentially making individuals more likely to enter violent situations and less able to skillfully deescalate dangerous situations.[98] FSW with drug addiction also are more likely to take on more risk, including risk of violence, if necessary in order to finance buying drugs; FSW who do not need to purchase drugs can afford to turn down riskier clients.[33]

Polyvictimization

Polyvictimization research has been underutilized to study exposures in adulthood and among FSW. Polyvictimization, i.e. experiencing multiple different forms of violence, crime, abuse, or victimization, arose in the field of child abuse research. Studying a single form of violence is problematic when other co-occurring forms of violence may contribute to negative health outcomes.[101] The groundbreaking Adverse Childhood Experiences (ACE) study used a dose-response framework to show that as the number of ACEs accumulated, the risk of myriad health problems in adulthood dramatically increased.[102] For instance, adults who had experienced four ACEs as children had 12.2 times higher odds of attempting suicide, 4.6 times higher odds of recent depression, 1.6 times higher odds of severe obesity, and 2.2 times the odds of current smoking, compared to adults who had not experienced any ACEs as children.[102] Polyvictimization during childhood has been linked to pregnancy,[103]

psychiatric disorders,[104] and delinquent behavior[104] in adolescence, and long-term outcomes including attempted suicide,[105] poor mental health,[106] and sexually transmitted infections[107] in adulthood. Experiencing one form of violence is a risk factor for experiencing other forms of violence, leading to a clustering of violence in individuals and an increasing cumulative burden on health. For instance, children who experience physical assault are five times more likely to have been sexually assaulted, 4 times more likely to have been maltreated, and 2.5 times more likely to witness violence.[108] Given the evidence described above as to the range and impact of distinct perpetrators of violence against FSW, the dissertation research is significant in applying a polyvictimization framework to a high-risk adult population, specifically FSW.

Syndemics

Syndemic theory has explored the intertwined issues of HIV, violence, and substance abuse, but has been underutilized among FSW. Syndemic theory describes any set of health issues that are 1) mutually reinforcing and enhancing, 2) synergistically producing excess burden of disease on the population, 3) influenced by structural violence and social inequality, and 4) so intertwined that they cannot be addressed in isolation.[109, 110] Since Merrill Singer first introduced the concept of syndemics in 1996 using the example of the substance abuse, violence, and AIDS (SAVA) syndemic,[109] it has been applied to a multitude of proposed syndemics, including asthma and influenza, hepatitis and HIV, and tuberculosis and HIV.[111] The literature on the SAVA syndemic has been most extensive in non-FSW populations, and quantitative literature has usually followed the same set of basic methods that have limitations; this dissertation responds in part to these challenges.

While the SAVA syndemic and syndemic theory have been underutilized among FSW, there is a fairly extensive literature applying a syndemic framework to men who have sex with men (MSM). The most common syndemic conditions examined among MSM include polydrug use, depression, sexual compulsivity, childhood sexual abuse, and intimate partner violence.[112-114] Other exposures examined

include alcohol use, sexually transmitted infections, stress, and emotional neglect.[115] The focus of the analysis is usually to understand how these exposures interact to produce HIV risk, and thus the outcome chosen is often HIV status, unprotected anal intercourse, or other HIV-related behaviors such as serosorting.[116] Urban, American, predominantly white MSM populations dominate the literature, although studies in developing countries are increasing.[117, 118]

While extensive qualitative work in syndemics has described the lived experiences of individuals subject to multiple syndemic conditions,[110] the qualitative literature is unable to quantify the tenet of syndemic theory that multiple syndemic conditions *synergistically* increase risks to health. Syndemic research is complicated by linguistic confusion over what is meant quantitatively by qualitative language around “synergistic” or “interacting” epidemics.[119, 120] There is no clear agreement about whether conceptual language around “interacting” epidemics should then translate into statistically significant multiplicative interaction terms in regression models, or if two distinct concepts are being conflated due to similar terminology.

Quantitative syndemic and polyvictimization analyses frequently use a linear dose-response method.[102, 112, 113, 121, 122] As with the ACEs framework, findings in syndemic analyses have consistently shown that as the number of syndemic conditions increases, so does HIV risk. However, the linear dose-response or additive model does not adequately operationalize synergy. It does not test for *excess* risk beyond the independent effects of each individual syndemic factor and cannot identify pairs of co-occurring exposures that exhibit a synergistic effect (beyond a proportionally additive effect) on health. The linear dose-response test only shows that there is more burden to health as the number of exposures rises.

The dose-response approach is also limited because a sum score of exposures implicitly treats all syndemic factors as interchangeable. This approach is limited because a) it models each exposure as having a unit effect on the outcome, even though some exposures might have a larger effect than others; b) it cannot identify the most important exposures or combinations of exposures to address using interventions; and c) it cannot identify pairs of co-occurring exposures that exhibit a synergistic, mutually

enhancing effect (beyond an additive effect) on health. Standard ACEs analyses have treated adverse experiences as different as having parents divorce and being sexually abused as interchangeable in expected impact on health. This lack of specificity has obscured important differences between factors within a given syndemic, diluting the ability to target interventions toward particularly potent syndemic exposures or co-occurring pairs of exposures that interact synergistically to produce excess risk.

Only a handful of syndemics articles have quantitatively investigated synergistic interaction.[123] Herrick used interaction analyses in her dissertation and is the only one to have examined both multiplicative and additive interaction between syndemic factors.[124] While hers was one of only 6 studies to date to find significant multiplicative interaction effects,[123, 125] she did not compute confidence intervals or p-values for her measures of additive interaction, leaving the reader unable to judge whether additive interaction is taking place. The dissertation work advances syndemic theory and methods by refining and implementing both additive and multiplicative interaction analyses, as well proposing a novel quadratic dose-response approach, to better understand how qualitative interaction between epidemics results in quantitative evidence of synergistic effects.

The application of a SAVA syndemic framework to women's HIV risk and FSW in particular lags behind. In a recent review of quantitative evidence for the SAVA syndemic among US women, only one of 45 articles focused specifically on FSW.[52] In a separate systematic review of the broader quantitative syndemics literature, just 14% of studies were among women.[123] Qualitative work among FSW has shown that sex work serves as “a mediating factor in the SAVA syndemic,” amplifying women's risks for violence, HIV, and substance use through complex pathways.[110] This dissertation builds on this qualitative evidence by investigating the SAVA syndemic in sex work context from a quantitative standpoint.

Theoretical framework

This study applies concepts from syndemic theory and polyvictimization to understand HIV risk among FSW. The SAVA syndemic model brings attention to the synergistic associations between violence, substance abuse, and HIV. However, for FSW, it is limited in conceptualizing violence as a single component rather than differentiating violence from different perpetrators, despite the different implications for HIV and substance use.[76] We propose a sex work-specific syndemic model that explicitly extends existing SAVA framework (Figure 2) to incorporate polyvictimization and distinguish the four most common types of violence – violence from clients, intimate partners, police, and pimps – in the model as separate, yet intertwined, exposures (Figure 3).

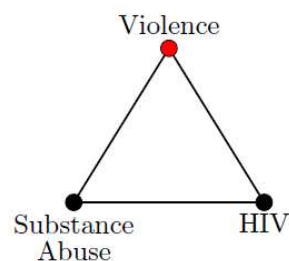


Figure 1.2: Original SAVA syndemic model proposed by Singer et al.

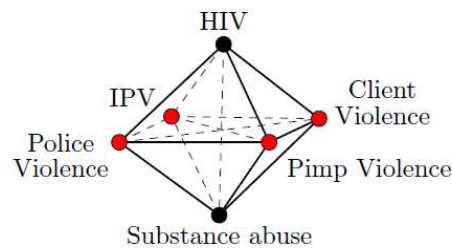


Figure 1.3: Extended syndemic model incorporating polyvictimization, as proposed in this work. We look separately at substance abuse-related HIV risk and sexual HIV risk in the analyses.

The analytic approach taken operationalizes concepts from syndemic theory and polyvictimization and extends common dose-response approaches. In this work, we build on recent analytic proposals[126] by proposing and implementing a comprehensive approach to assessing synergy. This approach avoids previously mentioned limitations of traditional syndemic and polyvictimization analyses, as it allows for uneven exposure effects, the identification of the most important exposures and exposure patterns, and the identification of synergistic effects between specific exposures. The proposed research is therefore novel in its extension of theory and methods and its application to FSW.

Russian context

Russia is a unique and complex setting for understanding violence and HIV in the context of sex work. Russia is one of just a few countries in the world where HIV prevalence and incidence are still increasing.[15, 16, 127, 128] Russia has the highest incidence in Europe; incident infections have risen on average almost 11% per year in the last decade, rising from 39,402 infections in 2005 to 98,177 in 2015.[129] Russia is transitioning toward a heterosexual contact-driven HIV epidemic from an injecting drug use-driven epidemic, particularly among women. In 2008, 63% of incident infections among women were due to sexual contact,[130] a number that may be increasing: Only 18.7% of prevalent infections among women in 2015 were due to injecting drug use.[16] Since 2012, foreign and multilateral donors have left or been ejected from the country, and the Russian government has not funded FSW-focused programs.[131] The government response to the HIV epidemic has been so anemic that the Russian government did not even issue an HIV strategy between 2006 and 2016. The 2016 strategy only makes a passing mention of vulnerable groups such as FSW and IDU, with no clear plan to address HIV in these populations.[15] Rather than committing to the UNAIDS goal of 90-90-90 (90% of people living with HIV diagnosed, 90% of those diagnosed on treatment, and 90% of those on treatment virally suppressed), it has suggested that it is targeting 60-60-60, which would be an improvement in the current treatment program quality but likely insufficient to yield dividends in reversing trends in incidence.[15]

HIV is prevalent among FSW, particularly among those who inject drugs. In the parent study for this dissertation, prevalence was 6.4%, 3.6%, and 1.6% in Kazan, Krasnoyarsk, and Tomsk, respectively, or 3.9% overall.[41] Earlier estimates from other cities showed an HIV prevalence among FSW ranging from 4.8% in Moscow[58] in 2005 to 48.1% among FSW who inject drugs in St. Petersburg in 2003.[132] The Russian government does not provide nationwide, FSW-specific surveillance figures.[16] Sex work is criminalized in Russia and punishable by a fine of 2000 rubles (\$60) while drug use is punishable with punitive detoxification programs, fines, or imprisonment.[133]

Injecting drug use is common among Russian FSW, with estimates including 17.7% lifetime use in Moscow[58] and 47.5% past-day use in St. Petersburg and Orenburg.[56] Recent research demonstrates prevalent physical and sexual violence against FSW.[41, 56, 58] Unfortunately, Russia has not reported HIV data for FSW, since 2012.[128] In addition to repressing HIV research for key populations, Russia has recently strengthened its laws against non-Russian citizens working with NGOs. The Russian Foreign Agent Law (July 2012)[134] and the Undesirable NGOs Law (May 2015)[135] have made international collaborations increasingly difficult. This study therefore importantly sheds light on the state of HIV prevention among Russian FSW.

Addressing violence is also complicated in the Russian context. A law passed in January 2017 partially decriminalized domestic violence unless it results in a “serious” injury or is a repeat offense. First-time, “minor” offenses are now only punishable with up to 15 days of jail time (previously punishable with up to 2 years of jail time) and a fine of up to 30,000 rubles (US\$500).[136] The Russian government does not have a system in place to conduct surveillance of domestic violence, though they released statistics in 2008 stating 14,000 women die yearly as a result of domestic violence.[137] A recent report found there are only 42 domestic violence shelters in all of Russia, comprising some 400 beds.[138] IPV has been shown in the Russian context to be associated with injecting drug use in a sample of STI patients[139] and with sex work in a sample of women living with HIV in Russia. [140]

Kazan (population 1,216,965) is the eighth largest city in Russia and is 500 miles east of Moscow. This site was more densely populated than the other two study sites, with more intensive street-based sex work activity and a larger IDU population. Tomsk (population 524,669) and Krasnoyarsk (population 1,035,528) are industrial centers in Siberia. All cities have significant sex work industries. Women typically recruit clients on the street, in saunas, in hotels, online, or from *tochkas* (areas along streets where sex workers gather and meet clients out of cars). The number of sex workers in Russia is thought to be steadily on the rise due to economic pressures, including globalization, increasing

unemployment, migration from rural to urban areas in search of work, and continuing ripples felt from the massive economic transition after the fall of the Soviet Union and from the recent financial crisis.[2]

References

1. UNAIDS. Fact sheet November 2016. Global HIV statistics. 2016.
2. Ward H, Aral S. Globalisation, the sex industry, and health. *Sexually transmitted infections*. 2006;82(5):345-7.
3. Baral S, Beyrer C, Muessig K, Poteat T, Wirtz AL, Decker MR, et al. Burden of HIV among female sex workers in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet infectious diseases*. 2012;12(7):538-49.
4. Gray RH, Wawer MJ, Brookmeyer R, Sewankambo NK, Serwadda D, Wabwire-Mangen F, et al. Probability of HIV-1 transmission per coital act in monogamous, heterosexual, HIV-1-discordant couples in Rakai, Uganda. *The Lancet*. 2001;357(9263):1149-53.
5. Baggaley RF, White RG, Boily M-C. HIV transmission risk through anal intercourse: systematic review, meta-analysis and implications for HIV prevention. *International journal of epidemiology*. 2010;dyq057.
6. UNAIDS. Global AIDS response progress reporting 2014: construction of core indicators for monitoring the 2011 UN political declaration on HIV/AIDS. 2014.
7. Voeten H, Egesah O, Varkevisser C, Habbema J. Female sex workers and unsafe sex in urban and rural Nyanza, Kenya: regular partners may contribute more to HIV transmission than clients. *Tropical Medicine & International Health*. 2007;12(2):174-82.
8. Deering KN, Bhattacharjee P, Bradley J, Moses SS, Shannon K, Shaw SY, et al. Condom use within non-commercial partnerships of female sex workers in southern India. *BMC public health*. 2011;11(Suppl 6):S11.
9. Murray L, Moreno L, Rosario S, Ellen J, Sweat M, Kerrigan D. The role of relationship intimacy in consistent condom use among female sex workers and their regular paying partners in the Dominican Republic. *AIDS and Behavior*. 2007;11(3):463-70.
10. Panchanadeswaran S, Johnson SC, Sivaram S, Srikrishnan AK, Latkin C, Bentley ME, et al. Intimate partner violence is as important as client violence in increasing street-based female sex workers' vulnerability to HIV in India. *International Journal of Drug Policy*. 2008;19(2):106-12.
11. Peitzmeier S, Mason K, Ceesay N, Diouf D, Drame F, Loum J, et al. A cross-sectional evaluation of the prevalence and associations of HIV among female sex workers in the Gambia. *International journal of STD & AIDS*. 2013;0956462413498858.
12. Rusakova M, Rakhmetova A, Strathdee SA. Why are sex workers who use substances at risk for HIV? *The Lancet*. 2014.
13. Patterson TL, Goldenberg S, Gallardo M, Lozada R, Semple SJ, Orozovich P, et al. Correlates of HIV, STIs and associated high risk behaviors among male clients of female sex workers in Tijuana, Mexico. *AIDS (London, England)*. 2009;23(13):1765.
14. Baral S, Logie CH, Grosso A, Wirtz AL, Beyrer C. Modified social ecological model: a tool to guide the assessment of the risks and risk contexts of HIV epidemics. *BMC Public Health*. 2013;13(1):482.
15. Clark F. Gaps remain in Russia's response to HIV/AIDS. *The Lancet*. 2016;388(10047):857.
16. Pokrovskiy V, Ladnaya N, Tushina O, Buravtsova E. HIV-Infection. Informational Bulletin #40 (ВИЧ-Инфекция. Информационный бюллетень №40). Moscow: Federal Scientific and Methodological Center for AIDS Prevention and Control (Федеральный научно-методический центр по профилактике и борьбе со СПИДом), 2015.

17. Grosso AL, Lei EL, Ketende SC, Peitzmeier S, Mason K, Ceesay N, et al. Correlates of condom use among female sex workers in The Gambia: results of a cross-sectional survey. *PeerJ*. 2015;3:e1076.
18. Fontanet AL, Saba J, Chandelying V, Sakondhavat C, Bhiraleus P, Rugpao S, et al. Protection against sexually transmitted diseases by granting sex workers in Thailand the choice of using the male or female condom: results from a randomized controlled trial. *Aids*. 1998;12(14):1851-9.
19. Hanenberg RS, Sokal D, Rojanapithayakorn W, Kunasol P. Impact of Thailand's HIV-control programme as indicated by the decline of sexually transmitted diseases. *The lancet*. 1994;344(8917):243-5.
20. Shannon K, Kerr T, Allinott S, Chettiar J, Shoveller J, Tyndall MW. Social and structural violence and power relations in mitigating HIV risk of drug-using women in survival sex work. *Social science & medicine*. 2008;66(4):911-21.
21. Rekart ML. Sex-work harm reduction. *The Lancet*. 2006;366(9503):2123-34.
22. Larney S, Mathers BM, Poteat T, Kamarulzaman A, Degenhardt L. Global Epidemiology of HIV Among Women and Girls Who Use or Inject Drugs: Current Knowledge and Limitations of Existing Data. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2015;69:S100-S9.
23. Sullivan S, Stephenson R. Perceived HIV Prevalence Accuracy and Sexual Risk Behavior Among Gay, Bisexual, and Other Men Who Have Sex with Men in the United States. *AIDS and Behavior*. 2017:1-9.
24. Wang B, Li X, McGuire J, Kamali V, Fang X, Stanton B. Understanding the dynamics of condom use among female sex workers in China. *Sexually transmitted diseases*. 2009;36(3):134-40.
25. Mooney A, Kidanu A, Bradley HM, Kumoji EK, Kennedy CE, Kerrigan D. Work-related violence and inconsistent condom use with non-paying partners among female sex workers in Adama City, Ethiopia. *BMC public health*. 2013;13(1):771.
26. Fitzgerald-Husek A, Martiniuk AL, Hinchcliff R, Aochamus CE, Lee RB. "I do what I have to do to survive": An investigation into the perceptions, experiences and economic considerations of women engaged in sex work in Northern Namibia. *BMC women's health*. 2011;11(1):35.
27. Rosenthal D, Oanh TTK. Listening to female sex workers in Vietnam: influences on safe-sex practices with clients and partners. *Sexual health*. 2006;3(1):21-32.
28. Baggaley RF, Boily M-C, White RG, Alary M. Risk of HIV-1 transmission for parenteral exposure and blood transfusion: a systematic review and meta-analysis. *Aids*. 2006;20(6):805-12.
29. UNAIDS. The Gap Report. http://www.unaids.org/sites/default/files/media_asset/UNAIDS_Gap_report_en.pdf: 2014.
30. Tang Z, Zhang C, Li X, Liu Y, Su S, Zhou Y, et al. HIV risk among female sex workers with different patterns of drug use behaviors in Southwest China: a cross-sectional study. *AIDS care*. 2014;(ahead-of-print):1-8.
31. Wirtz A, Peryshkina A, Moguilnyi V, Beyrer C, Decker M. Current and recent drug use intensifies sexual and structural HIV risk outcomes among female sex workers in the Russian Federation. *International Journal of Drug Policy*. 2015.
32. Medhi GK, Mahanta J, Kermode M, Paranjape RS, Adhikary R, Phukan SK, et al. Factors associated with history of drug use among female sex workers (FSW) in a high HIV prevalence state of India. *BMC public health*. 2012;12(1):273.
33. Strathdee SA, Philbin MM, Semple SJ, Pu M, Orozovich P, Martinez G, et al. Correlates of injection drug use among female sex workers in two Mexico-US border cities. *Drug and alcohol dependence*. 2008;92(1):132-40.
34. Ross MW, Crisp BR, Månsson S-A, Hawkes S. Occupational health and safety among commercial sex workers. 2012.
35. Platt L, Jolley E, Rhodes T, Hope V, Latypov A, Reynolds L, et al. Factors mediating HIV risk among female sex workers in Europe: a systematic review and ecological analysis. *BMJ open*. 2013;3(7).
36. Prüss-Ustün A, Wolf J, Driscoll T, Degenhardt L, Neira M, Calleja JMG. HIV due to female sex work: regional and global estimates. *PloS one*. 2013;8(5):e63476.

37. El-Bassel N, Shaw SA, Dasgupta A, Strathdee SA. Drug use as a driver of HIV risks: re-emerging and emerging issues. *Current Opinion in HIV and AIDS*. 2014;9(2):150-5.
38. Croxford S, Platt L, Hope VD, Cullen KJ, Parry JV, Ncube F. Sex work amongst people who inject drugs in England, Wales and Northern Ireland: Findings from a National Survey of Health Harms and Behaviours. *International Journal of Drug Policy*. 2014.
39. Lau JT, Tsui HY, Zhang Y, Cheng F, Zhang L, Zhang J, et al. Comparing HIV-related syringe-sharing behaviors among female IDU engaging versus not engaging in commercial sex. *Drug and alcohol dependence*. 2008;97(1):54-63.
40. UNODC. World drug report 2010. United Nations Publications; 2010.
41. Decker MR, Wirtz AL, Moguilnyi V, Peryshkina A, Ostrovskaya M, Nikita M, et al. Female sex workers in three cities in Russia: HIV prevalence, risk factors and experience with targeted HIV prevention. *AIDS and behavior*. 2014;18(3):562-72.
42. Móró L, Simon K, Sárosi P. Drug use among sex workers in Hungary. *Social Science & Medicine*. 2013;93:64-9.
43. Girchenko P, King EJ. Correlates of Double Risk of HIV Acquisition and Transmission Among Women who Inject Drugs in St. Petersburg, Russia. *AIDS and Behavior*. 2017;21(4):1054-8.
44. Goldenberg SM, Rangel G, Vera A, Patterson TL, Abramovitz D, Silverman JG, et al. Exploring the impact of underage sex work among female sex workers in two Mexico–US border cities. *AIDS and Behavior*. 2012;16(4):969-81.
45. Sarang A, Rhodes T, Platt L, Kirzhanova V, Shelkovnikova O, Volnov V, et al. Drug injecting and syringe use in the HIV risk environment of Russian penitentiary institutions: qualitative study. *Addiction*. 2006;101(12):1787-96.
46. Dittmore M. When sex work and drug use overlap. *Harm Reduction International*, 2013.
47. Lawrinson P, Ali R, Buavirat A, Chiamwongpaet S, Dvoryak S, Habrat B, et al. Key findings from the WHO collaborative study on substitution therapy for opioid dependence and HIV/AIDS. *Addiction*. 2008;103(9):1484-92.
48. Rhodes T. The 'risk environment': a framework for understanding and reducing drug-related harm. *International journal of drug policy*. 2002;13(2):85-94.
49. Rhodes T, Simic M. Transition and the HIV risk environment. *Bmj*. 2005;331(7510):220-3.
50. Decker MR, Crago A-L, Chu SK, Sherman SG, Seshu MS, Buthelezi K, et al. Human rights violations against sex workers: burden and effect on HIV. *The Lancet*. 2014.
51. Strathdee SA, West BS, Reed E, Moazan B, Azim T, Dolan K. Substance use and HIV among female sex workers and female prisoners: risk environments and implications for prevention, treatment, and policies. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2015;69:S110-S7.
52. Meyer JP, Springer SA, Altice FL. Substance abuse, violence, and HIV in women: a literature review of the syndemic. *Journal of Women's Health*. 2011;20(7):991-1006.
53. Campbell JC, Baty M, Ghandour RM, Stockman JK, Francisco L, Wagman J. The intersection of intimate partner violence against women and HIV/AIDS: a review. *International journal of injury control and safety promotion*. 2008;15(4):221-31.
54. Gielen AC, Ghandour RM, Burke JG, Mahoney P, McDonnell KA, O'Campo P. HIV/AIDS and Intimate Partner Violence Intersecting Women's Health Issues in the United States. *Trauma, Violence, & Abuse*. 2007;8(2):178-98.
55. Chersich M, Luchters S, Malonza I, Mwarogo P, King'Ola N, Temmerman M. Heavy episodic drinking among Kenyan female sex workers is associated with unsafe sex, sexual violence and sexually transmitted infections. *International journal of STD & AIDS*. 2007;18(11):764-9.
56. Odinokova V, Rusakova M, Urada LA, Silverman JG, Raj A. Police sexual coercion and its association with risky sex work and substance use behaviors among female sex workers in St. Petersburg and Orenburg, Russia. *International Journal of Drug Policy*. 2014;25(1):96-104.
57. Ulibarri MD, Strathdee SA, Ulloa EC, Lozada R, Fraga MA, Magis-Rodríguez C, et al. Injection drug use as a mediator between client-perpetrated abuse and HIV status among female sex workers in two Mexico-US border cities. *AIDS and Behavior*. 2011;15(1):179-85.

58. Decker MR, Wirtz AL, Baral SD, Peryshkina A, Mogilnyi V, Weber RA, et al. Injection drug use, sexual risk, violence and STI/HIV among Moscow female sex workers. *Sexually transmitted infections*. 2012;88(4):278-83.
59. Shannon K, Csete J. Violence, condom negotiation, and HIV/STI risk among sex workers. *JAMA*. 2010;304(5):573-4.
60. Argento E, Muldoon KA, Duff P, Simo A, Deering KN, Shannon K. High prevalence and partner correlates of physical and sexual violence by intimate partners among street and off-street sex workers. *PloS one*. 2014;9(7):e102129.
61. Braunstein SL, Ingabire CM, Geubbels E, Vyankandondera J, Umulisa M-M, Gahiro E, et al. High burden of prevalent and recently acquired HIV among female sex workers and female HIV voluntary testing center clients in Kigali, Rwanda. *PloS one*. 2011;6(9):e24321.
62. Garcia-Moreno C, Jansen HA, Ellsberg M, Heise L, Watts CH. Prevalence of intimate partner violence: findings from the WHO multi-country study on women's health and domestic violence. *The Lancet*. 2006;368(9543):1260-9.
63. Mayhew S, Collumbien M, Qureshi A, Platt L, Rafiq N, Faisel A, et al. Protecting the unprotected: mixed-method research on drug use, sex work and rights in Pakistan's fight against HIV/AIDS. *Sexually transmitted infections*. 2009;85(Suppl 2):ii31-ii6.
64. Deering KN, Bhattacharjee P, Mohan H, Bradley J, Shannon K, Boily M-C, et al. Violence and HIV risk among female sex workers in Southern India. *Sexually transmitted diseases*. 2013;40(2):168-74.
65. El-Bassel N, Witte SS, Wada T, Gilbert L, Wallace J. Correlates of partner violence among female street-based sex workers: substance abuse, history of childhood abuse, and HIV risks. *AIDS patient care and STDs*. 2001;15(1):41-51.
66. Hong Y, Zhang C, Li X, Liu W, Zhou Y. Partner violence and psychosocial distress among female sex workers in China. *PloS one*. 2013;8(4):e62290.
67. Pack AP, L'Engle K, Mwarogo P, Kingola N. Intimate partner violence against female sex workers in Mombasa, Kenya. *Culture, health & sexuality*. 2014;16(3):217-30.
68. Choudhury SM, Anglade D, Park K. From violence to sex work: agency, escaping violence, and HIV risk among establishment-based female sex workers in Tijuana, Mexico. *Journal of the Association of Nurses in AIDS Care*. 2013;24(4):368-82.
69. Hawkes S, Collumbien M, Platt L, Lalji N, Rizvi N, Andreasen A, et al. HIV and other sexually transmitted infections among men, transgenders and women selling sex in two cities in Pakistan: a cross-sectional prevalence survey. *Sexually Transmitted Infections*. 2009;85(Suppl 2):ii8-ii16.
70. Esausquin JT, Reed E, Blankenship KM. Police-related experiences and HIV risk among female sex workers in Andhra Pradesh, India. *Journal of Infectious Diseases*. 2011;204(suppl 5):S1223-S8.
71. Pando MA, Coloccini RS, Reynaga E, Fermepin MR, Vaulet LG, Kochel TJ, et al. Violence as a barrier for HIV prevention among female sex workers in Argentina. *PloS one*. 2013;8(1):e54147.
72. Surratt HL, Kurtz SP, Chen M, Mooss A. HIV risk among female sex workers in Miami: the impact of violent victimization and untreated mental illness. *AIDS care*. 2012;24(5):553-61.
73. Ratinthorn A, Meleis A, Sindhu S. Trapped in circle of threats: violence against sex workers in Thailand. *Health care for women international*. 2009;30(3):249-69.
74. Beletsky L, Lozada R, Gaines T, Abramovitz D, Staines H, Vera A, et al. Syringe confiscation as an HIV risk factor: the public health implications of arbitrary policing in Tijuana and Ciudad Juarez, Mexico. *Journal of Urban Health*. 2013;90(2):284-98.
75. Crago A-L. "Bitches Killing the Nation": Analyzing the Violent State-Sponsored Repression of Sex Workers in Zambia, 2004–2008. *Signs*. 2014;39(2):365-81.
76. Decker MR, Pearson E, Illangasekare SL, Clark E, Sherman SG. Violence against women in sex work and HIV risk implications differ qualitatively by perpetrator. *BMC public health*. 2013;13(1):876.
77. Shannon K, Strathdee SA, Shoveller J, Rusch M, Kerr T, Tyndall MW. Structural and environmental barriers to condom use negotiation with clients among female sex workers: implications for HIV-prevention strategies and policy. *American journal of public health*. 2009;99(4):659.

78. Kenya FIDA. Documenting human rights violations of sex workers in Kenya. Nairobi: Open Society Foundation, 2008.
79. Crago A. Arrest the violence: Human rights abuses against sex workers in Eastern Europe and Central Asia. Sex Workers' Rights Advocacy network (SWAn). 2009.
80. Shannon K, Strathdee SA, Goldenberg SM, Duff P, Mwangi P, Rusakova M, et al. Global epidemiology of HIV among female sex workers: influence of structural determinants. *The Lancet*. 2015;385(9962):55-71.
81. Beattie TS, Bhattacharjee P, Ramesh B, Gurnani V, Anthony J, Isac S, et al. Violence against female sex workers in Karnataka state, south India: impact on health, and reductions in violence following an intervention program. *BMC public health*. 2010;10(1):476.
82. Reza-Paul S, Lorway R, O'Brien N, Lazarus L, Jain J, Bhagya M, et al. Sex worker-led structural interventions in India: a case study on addressing violence in HIV prevention through the Ashodaya Samithi collective in Mysore. *The Indian journal of medical research*. 2012;135(1):98.
83. Ellsberg M, Arango DJ, Morton M, Gennari F, Kiplesund S, Contreras M, et al. Prevention of violence against women and girls: what does the evidence say? *The Lancet*. 2014.
84. Decker MR, McCauley HL, Phuengsamran D, Janyam S, Seage GR, Silverman JG. Violence victimisation, sexual risk and sexually transmitted infection symptoms among female sex workers in Thailand. *Sexually Transmitted Infections*. 2010;86(3):236-40.
85. Swain SN, Saggurti N, Battala M, Verma RK, Jain AK. Experience of violence and adverse reproductive health outcomes, HIV risks among mobile female sex workers in India. *BMC Public Health*. 2011;11(1):357.
86. Shannon K, Kerr T, Strathdee SA, Shoveller J, Montaner JS, Tyndall MW. Prevalence and structural correlates of gender based violence among a prospective cohort of female sex workers. *BMJ*. 2009;339.
87. Lang DL, Salazar LF, DiClemente RJ, Markosyan K. Gender based violence as a risk factor for HIV-associated risk behaviors among female sex workers in Armenia. *AIDS and Behavior*. 2013;17(2):551-8.
88. Shahmanesh M, Patel V, Mabey D, Cowan F. Effectiveness of interventions for the prevention of HIV and other sexually transmitted infections in female sex workers in resource poor setting: a systematic review. *Tropical Medicine & International Health*. 2008;13(5):659-79.
89. Campbell JC, Lucea MB, Stockman JK, Draughon JE. Forced sex and HIV risk in violent relationships. *American journal of reproductive immunology*. 2013;69(s1):41-4.
90. Stockman JK, Lucea MB, Campbell JC. Forced sexual initiation, sexual intimate partner violence and HIV risk in women: a global review of the literature. *AIDS and Behavior*. 2013;17(3):832-47.
91. Wulfert E, Wan CK. Condom use: A self-efficacy model. *Health Psychology*. 1993;12(5):346-53.
92. Swan H, O'Connell DJ. The impact of intimate partner violence on women's condom negotiation efficacy. *Journal of interpersonal violence*. 2012;27(4):775-92.
93. Decker MR, McCauley HL, Phuengsamran D, Janyam S, Silverman JG. Sex trafficking, sexual risk, sexually transmitted infection and reproductive health among female sex workers in Thailand. *Journal of epidemiology and community health*. 2010.
94. Strathdee SA, Crago A-L, Butler J, Bekker L-G, Beyrer C. Dispelling myths about sex workers and HIV. *The Lancet*. 2015;385(9962):4-7.
95. Campbell JC. Health consequences of intimate partner violence. *The Lancet*. 2002;359(9314):1331-6.
96. Jewkes RK, Levin JB, Penn-Kekana LA. Gender inequalities, intimate partner violence and HIV preventive practices: findings of a South African cross-sectional study. *Social science & medicine*. 2003;56(1):125-34.
97. Zhang C, Li X, Hong Y, Chen Y, Liu W, Zhou Y. Partner violence and HIV risk among female sex workers in China. *AIDS and Behavior*. 2012;16(4):1020-30.

98. El-Bassel N, Gilbert L, Wu E, Go H, Hill J. Relationship between drug abuse and intimate partner violence: a longitudinal study among women receiving methadone. *American Journal of Public Health*. 2005;95(3):465-70.
99. Shannon K, Rusch M, Shoveller J, Alexson D, Gibson K, Tyndall MW. Mapping violence and policing as an environmental–structural barrier to health service and syringe availability among substance-using women in street-level sex work. *International Journal of Drug Policy*. 2008;19(2):140-7.
100. Silverman JG, Raj A, Cheng DM, Decker MR, Coleman S, Bridden C, et al. Sex trafficking and initiation-related violence, alcohol use, and HIV risk among HIV-infected female sex workers in Mumbai, India. *Journal of Infectious Diseases*. 2011;204(suppl 5):S1229-S34.
101. Finkelhor D, Ormrod RK, Turner HA. Lifetime assessment of poly-victimization in a national sample of children and youth. *Child abuse & neglect*. 2009;33(7):403-11.
102. Felitti M, Vincent J, Anda M, Robert F, Nordenberg M, Williamson M, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American journal of preventive medicine*. 1998;14(4):245-58.
103. Hillis SD, Anda RF, Dube SR, Felitti VJ, Marchbanks PA, Marks JS. The association between adverse childhood experiences and adolescent pregnancy, long-term psychosocial consequences, and fetal death. *Pediatrics*. 2004;113(2):320-7.
104. Ford JD, Elhai JD, Connor DF, Frueh BC. Poly-victimization and risk of posttraumatic, depressive, and substance use disorders and involvement in delinquency in a national sample of adolescents. *Journal of Adolescent Health*. 2010;46(6):545-52.
105. Dube SR, Anda RF, Felitti VJ, Chapman DP, Williamson DF, Giles WH. Childhood abuse, household dysfunction, and the risk of attempted suicide throughout the life span: findings from the Adverse Childhood Experiences Study. *Jama*. 2001;286(24):3089-96.
106. Edwards VJ, Holden GW, Felitti VJ, Anda RF. Relationship between multiple forms of childhood maltreatment and adult mental health in community respondents: results from the adverse childhood experiences study. *American Journal of Psychiatry*. 2003;160(8):1453-60.
107. Hillis SD, Anda RF, Felitti VJ, Nordenberg D, Marchbanks PA. Adverse childhood experiences and sexually transmitted diseases in men and women: a retrospective study. *Pediatrics*. 2000;106(1):e11-e.
108. Finkelhor D, Turner H, Ormrod R, Hamby SL. Violence, abuse, and crime exposure in a national sample of children and youth. *Pediatrics*. 2009;124(5):1411-23.
109. Singer M. A dose of drugs, a touch of violence, a case of AIDS: conceptualizing the SAVA syndemic. *Free Inquiry in Creative Sociology*. 1996;24(2):99-110.
110. Romero-Daza N, Weeks M, Singer M. "Nobody gives a damn if I live or die": violence, drugs, and street-level prostitution in inner-city Hartford, Connecticut. *Medical anthropology*. 2003;22(3):233-59.
111. Singer M. Introduction to syndemics: A critical systems approach to public and community health: John Wiley & Sons; 2009.
112. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *American journal of public health*. 2003;93(6):939-42.
113. Parsons JT, Grov C, Golub SA. Sexual compulsivity, co-occurring psychosocial health problems, and HIV risk among gay and bisexual men: further evidence of a syndemic. *American Journal of Public Health*. 2012;102(1):156-62.
114. Oldenburg CE, Perez-Brumer AG, Reisner SL. Poverty matters: contextualizing the syndemic condition of psychological factors and newly diagnosed HIV infection in the United States. *AIDS*. 2014;28(18):2763-9.
115. Jie W, Ciyong L, Xueqing D, Hui W, Lingyao H. A syndemic of psychosocial problems places the MSM (men who have sex with men) population at greater risk of HIV infection. *PloS one*. 2012;7(3):e32312.

116. Kurtz SP, Buttram ME, Surratt HL, Stall RD. Resilience, syndemic factors, and serosorting behaviors among HIV-positive and HIV-negative substance-using MSM. *AIDS education and prevention: official publication of the International Society for AIDS Education*. 2012;24(3):193.
117. Guadamuz T, McCarthy K, Wimonasate W, Thienkrua W, Varangrat A, Chaikummao S, et al. Psychosocial health conditions and HIV prevalence and incidence in a cohort of men who have sex with men in Bangkok, Thailand: Evidence of a syndemic effect. *AIDS and Behavior*. 2014;18(11):2089-96.
118. Biello KB, Colby D, Closson E, Mimiaga MJ. The syndemic condition of psychosocial problems and HIV risk among male sex workers in Ho Chi Minh City, Vietnam. *AIDS and Behavior*. 2014;18(7):1264-71.
119. Bauer GR. Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity. *Social science & medicine*. 2014;110:10-7.
120. Blot WJ, Day NE. Synergism and interaction: are they equivalent? *American Journal of Epidemiology*. 1979;110(1):99-100.
121. Egan JE, Frye V, Kurtz SP, Latkin C, Chen M, Tobin K, et al. Migration, neighborhoods, and networks: approaches to understanding how urban environmental conditions affect syndemic adverse health outcomes among gay, bisexual and other men who have sex with men. *AIDS and Behavior*. 2011;15(1):35-50.
122. Brennan J, Kuhns LM, Johnson AK, Belzer M, Wilson EC, Garofalo R. Syndemic theory and HIV-related risk among young transgender women: the role of multiple, co-occurring health problems and social marginalization. *American journal of public health*. 2012;102(9):1751-7.
123. Tsai AC, Mendenhall E, Trostle JA, Kawachi I. Co-occurring epidemics, syndemics, and population health. *The Lancet*. 2017;389(10072):978-82.
124. Herrick A. Syndemic processes among young men who have sex with men (MSM): Pathways toward risk and resilience: University of Pittsburgh; 2011.
125. Tsai AC, Burns BF. Syndemics of psychosocial problems and HIV risk: a systematic review of empirical tests of the disease interaction concept. *Social Science & Medicine*. 2015;139:26-35.
126. Tsai AC, Venkataramani AS. Syndemics and health disparities: a methodological note. *AIDS and Behavior*. 2016;20(2):423-30.
127. USAID. HIV/AIDS Health Profile: Europe and Eurasia Region. 2012.
128. UNAIDS. Report on the Global AIDS Epidemic. Geneva: 2012.
129. European Centre for Disease Prevention and Control, WHO Regional Office for Europe. HIV/AIDS surveillance in Europe 2015. Stockholm:: 2016.
130. UNAIDS. Country Progress Report of the Russian Federation on the Implementation of the Declaration of Commitment on HIV/AIDS. Moscow: 2008.
131. Cohen J. Praised russian prevention program faces loss of funds. *Science*. 2010;329(5988):168-.
132. Smolskaya T, Yakovleva A, Kasumov V, Gheorgitsa S. HIV sentinel surveillance in high-risk groups in Azerbaijan, Republic of Moldova and in the Russian Federation. *Europe: World Health Organisation (WHO)*. 2004.
133. United States Department of State. International Narcotics Control Strategy Report. 2014.
134. Human Rights Watch. Russia: Government against rights groups <http://www.hrw.org/news/2015/05/20/russia-government-against-rights-groups2015>.
135. Grove T. Russia's Putin Signs New Law Against 'Undesirable' NGOs. *Wall Street Journal*. 2015.
136. Solomon F. Vladimir Putin Just Signed Off on the Partial Decriminalization of Domestic Abuse in Russia. *Time [Internet]*. 2017.
137. Violence against women in the Russian Federation: Alternative report to the United Nations Committee on the Elimination of Discrimination Against Women [Internet]. 2010. Available from: http://www2.ohchr.org/english/bodies/cedaw/docs/ngos/ANNANCPV_RussianFederation46.pdf
138. Lesur M, Stelmaszek B, Golden I. Country report 2013: Reality Check on European Services for Women and Children Survivors of Violence. Vienna: 2014.

139. Zhan W, Hansen NB, Shaboltas AV, Skochilov RV, Kozlov AP, Krasnoselskikh TV, et al. Partner violence perpetration and victimization and HIV risk behaviors in St. Petersburg, Russia. *Journal of traumatic stress*. 2012;25(1):86-93.
140. Urada L, Raj A, Cheng D, Quinn E, Briden C, Blokhina E, et al. History of intimate partner violence is associated with sex work but not sexually transmitted infection among HIV-positive female drinkers in Russia. *International journal of STD & AIDS*. 2013;24(4):287-92.

2. Methods

Study design overview

The thesis research is a secondary data analysis of an existing study[1] led by the student's adviser, Dr. Michele Decker. Data were collected July 25th through September 30th, 2011 using respondent-driven sampling to recruit a sample of n=754 FSW from Tomsk, Kazan, and Krasnoyarsk, Russia as part of a large-scale program evaluation for Global Fund program activities called Global Efforts Against HIV/AIDS in Russia (GLOBUS). The survey collected detailed data on sex work context, including exposure to violence. This study was cross-sectional with a single study visit.

Sample

Study setting

Kazan (population 1,216,965) is the eighth largest city in Russia and is 500 miles east of Moscow. This site was more densely populated than the other two sites, with more intensive street-based sex work activity and a larger IDU population. Tomsk and Krasnoyarsk are located in Siberia. Tomsk (population 524,669) is the smallest, least industrial site and boasts several universities. Krasnoyarsk (population 1,035,528) is an industrial center located along the Trans-Siberian railway; historically Krasnoyarsk was the site of a gulag forced labor camp. All cities have significant sex work industries. Sex work is criminalized in Russia and punishable by a fine of 2000 rubles (\$60), while drug use is punishable with punitive detoxification programs, fines, or imprisonment.[2]

In qualitative formative work, FSW in these cities described recruiting clients on the street, in saunas, hotels, online, or from *tochkas* (areas along streets where sex workers gather and meet clients out of cars). Women who worked with pimps, momkas, or protection gangs shared up to 50% of their earnings with these actors. Although some women described this protection as helpful, many found the relationship financially exploitative, provided insufficient protection from client violence, and carried an

expectation of providing free sex to the gang. Women who used drugs described unsafe injection practices and needle sharing as common and believed it to be a larger HIV risk than sexual exposure from clients.[1]

Study partners and context

The study was conducted in partnership with a consortium of HIV organizations in Russia called the Open Health Institute (OHI) that began in 2004. The aim of this consortium was to provide integrated HIV prevention interventions for key populations, including female sex workers. This program, called GLOBUS, was implemented in 10 regions of Russia by the OHI and led by AIDSInfoshare, a Moscow-based organization. Interventions offered by the program included education, HIV counselling and testing, diagnosis and treatment of STIs (by confidential doctors), and psychosocial support. The program reached over 15,000 sex workers between 2004 and 2007, or an estimated 57% of sex workers in the cities where services were offered. In 2010, AIDSInfoshare sought collaboration with the Johns Hopkins School of Public Health (JHSPH) to evaluate the program, inclusive of study design, training, and data analysis for program evaluation. The primary objective of the parent study was to evaluate GLOBUS by assessing program coverage, HIV knowledge, risk behaviors, condom use, and HIV prevalence among FSWs.

Formative research

Extensive formative research informed survey development and implementation.[1] Using focus groups (n=11) and individual interviews with FSW and service providers (n=35), this formative phase affirmed clients, intimate partners, pimps and *momkas* (female pimps), and police as substantive sources of violence in this population.[1]

Eligibility criteria

Study participants were non-transgender women over 18 years old, living or working in Kazan, Krasnoyarsk, or Tomsk, and had traded sex for money, drugs or shelter within the past 3 months.

Eligibility was not restricted by whether participants had used AIDSInfoShare services, by whether they possessed official documentation papers (propiska), by their sexual orientation, or by their sexual behavior aside from recent sex work.

Study recruitment

Recruitment (July 25th through September 30th, 2011) was via respondent-driven sampling (RDS)[3] at each site, with respondents given 5 recruitment coupons each. RDS is a controlled chain-referral peer recruitment strategy similar to snowball sampling, but where each participant is only allowed to recruit a certain number of peers up to the number of coupons given to each participant. This strategy promotes long recruitment chains, i.e. waves of recruitment beyond the original seeds, which facilitates access to portions of the population who may be less accessible to service providers and only accessible via peer recruitment. RDS was chosen due to the difficulty of creating a sampling frame and using random sampling in this hard-to-reach population.[3] RDS recruitment can also minimize breaches to confidentiality by having peers recruit one another discreetly, rather than having study staff approach potential participants in public places where their participation in the study may be noted by others.

Seeds were purposively selected by local partners to maximize diversity, including street and off-street sex work and injecting and non-injecting FSW. Because recruitment was conducted as for respondent-driven sampling, all recruitment was conducted by participants, and there was no passive or active recruitment by study staff after initial selection of seeds.

Because cash payment was considered inappropriate in this setting, participants were remunerated in the form of gifts. Women received a small gift (<\$5USD) for participation. There was no secondary incentive for recruitment of peers.

Data collection

Consent process

All study staff were thoroughly trained in ethics and safety, including undergoing CITI certification. A waiver of written informed consent was obtained to protect confidentiality. The consent process for all phases was conducted in Russian using oral consent scripts by trained staff members. A paper copy of the study information and a listing of names and local numbers of study staff to call with questions or concerns was available to participants.

Survey administration

The survey was developed in English, translated into Russian and piloted and revised before implementation. Study interviewers were local Russian NGO staff trained by Hopkins staff. Interviews in Tomsk and Krasnoyarsk took place in the local NGO's office; in Kazan interviews were also conducted in a mobile unit at locations across the city due to the remoteness of the local office. Interviews were self-administered on a computer, without audio assistance, and took 20-30 minutes, followed by OraQuick HIV testing. Participants had the option of asking questions to the interviewer during the survey, as well as to refuse to answer any question. A few surveys were completed via pencil and paper due to participant preference or logistical reasons. After completion, participants were provided with the incentive and with information on local resources for HIV and violence.

Measures

Key violence exposures

The violence exposures are lifetime exposure to intimate partner violence (physical), client violence (physical or sexual), pimp/momka violence (physical or sexual), and police violence (sexual) (See Table 1). Extensive formative research identified these types of violence as most relevant in the lives of FSW in this setting. Measures are based on the Conflicts Tactics Scale 2 (CTS-2) which asks about specific behaviors rather than asking about abuse generally.[4] The CTS-2 is the standard in violence research,[5] and CTS-2-based questionnaires have been used successfully in diverse samples of FSW.[6,

7] Formative research also informed development of setting-specific behaviors, such as common types of physical abuse from pimps or momkas and *subbotnik*, or coerced sex with police officers in order to avoid arrest.[1]

We define violence types by perpetrator rather than classifying as physical, sexual, or psychological because disaggregating violence by perpetrator type is critical for designing violence and HIV prevention interventions. Violence from one type of perpetrator requires different interventions than violence from another type of perpetrator. For example, interventions to reduce client violence may include structural changes to sex work venues such as requiring client sign-in, emergency call buttons, and supportive managerial policies and crisis response.[8] Meanwhile, interventions to reduce police violence may involve training police, policy advocacy to change laws allowing condoms as evidence of sex work, and facilitating sex worker-police partnerships.[9, 10] Additionally, violence from each of these sources is qualitatively different in intensity, context, risk factors, and implications for HIV. For instance, sexual violence from clients often involves pressure to perform higher-risk sexual acts, such as anal or unprotected sex, or sex with multiple clients at the same time.[11-13] In contrast, police violence is linked to HIV risk via direct exposure to unprotected sexual violence, harassment and seizure of condoms or syringes as evidence,[14] aggressive policing practices that lead sex workers to move to more clandestine locations where they may be forced to take riskier or more violent clients,[13-15] and arrest and placement in high-risk detention centers where needle sharing and further violence are common.[16-18] This focus on perpetrator-specific violence and interventions matches an overall shift in the violence research field to broaden its focus from interventions that provide services to survivors of violence to primary prevention of violence.[19] Recent evidence from a systematic review has shown that interventions that attempt to protect potential victims from abuse have limited success at reducing victimization, and that primary prevention interventions should focus on potential perpetrators.[19]

Table 2.1: Survey items measuring violence victimization exposures of interest.

Perpetrator	Measure
Intimate partner	Physical violence: Think about your boyfriends, husband, or other people you have dated. Have you been hit, pushed, slapped, or otherwise physically hurt by a boyfriend, husband, or someone you were dating?
Client	Physical violence: Have you been hit, pushed, slapped, or otherwise physically hurt by a client?
	Severe physical violence: Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a client?
	Forced vaginal sex: Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>vaginal</i> sex when you didn't want to?
	Forced anal sex: Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>anal</i> sex when you didn't want to?
	Coerced vaginal sex*: Have you had a client pressure you for or insist on <i>vaginal</i> sex when you did not want to (but did not use physical force)?
	Coerced anal sex*: Have you had a client pressure you for or insist on <i>anal</i> sex when you did not want to (but did not use physical force)?
Pimp/momka	Physical violence: Have you been hit, pushed, slapped, or otherwise physically hurt by a pimp/momka?
	Severe physical violence: Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a pimp/momka?
	Forced sex, site unspecified: Has your pimp ever forced you to have sex when you did not want to?
Police	Subbotnik: How many times have you been involved in a subbotnik (asked to provide sex to police or militia to avoid incarceration or arrest)?
	Police coerced sex: In the past 6 months, have you had to pay or compensate the police for the ability to sell sex or stand on the street? Options include: Yes, had to provide sex

* Measure included in survey, but not included in final variable definition as used in the main analyses of the dissertation. See Measure calibration section below.

Measure calibration and sensitivity analysis

The question sets available in the survey to measure violence by the four different types of perpetrators were not identical and are compared in Table 2 and Figure 1, with the text of the questions in

Table 1. The number of questions available for client violence (6) was greater than the number of questions available for police (2), intimate partner (1), and pimp (3) violence. Further, for some types of perpetrators only physical violence was assessed (intimate partners), for other types only sexual violence was assessed (police violence), and for others both were assessed (client and pimp violence). Reduced question sets for some perpetrators were due to survey space constraints. Wherever possible, the study team decided which questions to retain in reduced question sets based on formative research. For instance, formative work showed that FSW were primarily concerned about sexual rather than physical violence from police, so questions about sexual violence were prioritized.

The differences in question sets across perpetrators raised questions about how to maximize comparability of the main exposure variables of client, police, intimate partner, and pimp violence. For instance, using 6 questions to assess physical and sexual violence from clients would presumably create a more sensitive measure than using just 1 question to assess only physical violence from intimate partners. If comparability is the only concern, question sets for all perpetrators can be reduced to the lowest common denominator of a single question for each of the four types of perpetrators. However, while maximally comparable, this also reduces the validity of the measures for client, police, and pimp violence where we have additional data available that we are not making use of.

To strike a balance between these competing concerns, the question set for client violence was reduced from 6 to 4 questions to make it more comparable to the other types of violence both in the nature of assessment and the total number of items used. The two questions that were removed from the 6-item assessment were on coerced vaginal or anal sex, “Have you had a client pressure you for or insist on *vaginal* sex when you did not want to (but did not use physical force)?” and “Have you had a client pressure you for or insist on *anal* sex when you did not want to (but did not use physical force)?” Clients were the only perpetrator type for which there was a question around being coerced into sex in this way, so these questions were the least comparable across perpetrator types. The final 4-item client violence measure therefore assessed forced sex but not coerced sex.

Police violence was assessed via two items focused on sexual violence per the formative research. The first item assessed coerced sex within a broad class of police extortion including being pressured to provide sex to police in exchange for avoiding arrest (i.e., coerced sex), as well as pressure to provide money or information about crimes for the same purpose. This assessment was limited to the past 6 months. The other police violence item (subbotnik) stems from formative research; the term *subbotnik* originally referred to days of mandatory unpaid labor for the state under the Soviet regime. In a sex-work context, subbotnik refers to often-violent, police-initiated, forced or coerced sex, often implicitly or explicitly in exchange for non-arrest.[1, 20]

The final measures used in the dissertation were therefore defined as binary exposures answering affirmatively to one of 4 questions regarding client violence (physical violence, severe physical violence, forced vaginal sex, and forced anal sex), one of two question specific to police violence (subbotnik or coerced sex), one question on intimate partner violence (physical violence), and one of 3 questions specific to pimp violence (physical violence, severe physical violence, and forced sex from unspecified site). For each form of violence, there was a multipart question that asked about violence in the past 6 months and violence more than 6 months ago. Participants were considered to have experienced lifetime violence if they reported experiencing violence in either time period.

Table 2.2: Comparison of prevalence of lifetime violence items by perpetrator.

	Client violence n/N (%)	Police violence n/N (%)	IPV n/N (%)	Pimp violence n/N (%)
Physical violence	207/747 (27.7)*	N/A	105/675 (15.6)	71/738 (9.6)
Severe physical violence	117/747 (15.7)*	N/A	N/A	36/735 (4.9)
Forced vaginal sex	88/735 (12.0)*	N/A	N/A	N/A
Forced anal sex	39/689 (5.7)*	N/A	N/A	N/A
Forced sex, site unspecified	N/A	N/A	N/A	76/750 (10.1)

Coerced vaginal sex	193/737 (26.2)	N/A	N/A	N/A
Coerced anal sex	109/697 (15.6)	N/A	N/A	N/A
Police subbotnik	N/A	117/738 (15.8)	N/A	N/A
Police coerced sex	N/A	38/745 (5.1%)	N/A	N/A
Summary measures				
4-item client violence measure used in main analyses	239/754 (31.7)			
6-item client violence measure used in sensitivity analysis	333//754 (44.2)			
3-item pimp violence measure				86/754 (11.4)
2-item police violence measure		121/754 (16.0)		

* These four items were used to create the 4-item client violence measure used in main analyses
Denominators for individual item prevalences fluctuate by question based on missing data. Summary measure prevalences were calculated using the multiply imputed dataset; as such n/N provided are approximations.

In sensitivity analyses, we compared the full 6-item client violence assessment inclusive of two items specific to pressured or coerced vaginal or anal sex with the 4-item assessment used for the primary analysis. Prevalence of client violence was higher with the 6-item client violence measure (44.2% versus 31.7%, Table 2). Analytic findings using the 6-item definition of client violence were qualitatively similar to results using the 4-item measure in all three aims of the dissertation. Appendix Figure A1 shows distribution of violence types in the sample in the 4-item definition (and using the 6-item definition as part of the sensitivity analysis. Results of this sensitivity analysis affirmed that using a reduced 4-question set to measure client violence in the main analysis maximizes comparability without introducing major differences in the analytic conclusions drawn by the study.

Key HIV outcomes

Three outcome variables were examined. Outcome measures are current or within the past six months.

The drug-related HIV risk outcome is injecting drugs in the past 6 months. Respondents were asked “Have you ever used a needle to inject drugs?” and given the options of “Yes, in the past 6 months,” “Yes, not in the past 6 months, but before that,” and “no.” Given the high levels of injecting drug use among FSW in the Russian context,[21] this is a key source of HIV risk. In this dataset, over half the women who have used drugs in the past 6 months also reported sharing syringes during that time frame.[22] While syringe sharing is arguably a more specific HIV risk outcome, injecting drug use is also a valid HIV risk behavior and may be less subject to systematic reporting biases or recall reliability issues (i.e. there are likely some FSW who reported that they injected but either did not remember or were unwilling to report sharing syringes).[23]

The sexual HIV risk outcomes are 1) inconsistent condom use with clients in the past 6 months and 2) inconsistent condom use with current main non-paying sex partner (i.e. intimate partner). Respondents were asked “Over the past 6 months, how often do you use a condom with clients during vaginal sex?” and “Over the past 6 months, how often do you use a condom with clients during anal sex?” and given response options of always, often, half the time, sometimes, rarely, and never. Participants who responded “always” to both questions are considered consistent condom users with clients; otherwise they are considered to have the outcome of inconsistent condom use with clients.

To assess inconsistent condom use with an intimate partner, participants were asked to think of their current, main, nonpaying sexual partner and asked “How often do you use condoms with this partner?” Participants who stated that they “always” use condoms are considered consistent condom users with their intimate partner; otherwise they are considered to have the outcome of inconsistent condom use with their intimate partner. Assessing condom usage with clients is one of the UNAIDS core indicators.[24] Unprotected sex with intimate partners is an important HIV risk source given higher

frequency of unprotected sex with intimate partners as compared to clients[25, 26] and association of intimate partners with HIV risk for FSW.[27-29]

Covariates and potential confounders

Potential confounders were identified based on a review of the literature and available variables measured in the survey. These included 13 variables: age,[30, 31] engaging in street-based sex work,[21, 32-35] average number of vaginal or anal sex clients per night,[20] having another income besides sex work,[22, 33] current number of non-paying intimate partners,[28] duration of time in sex work,[22] education level,[36] age of entry into sex work,[37, 38] relationship status,[22, 39] monthly salary,[40] being Russian versus being born in another country,[40] having *propiska* (official documentation papers),[40] and using alcohol during sex work.[21, 41] We used bivariate log-binomial regression to determine if each of these 13 potential confounders were associated with any of the 4 primary violence exposures at $p < 0.10$. The last 3 variables (being Russian, having *propiska*, and using alcohol during sex work) were not associated at $p < 0.10$ with any of the 4 primary exposure variables and were discarded from the list of potential confounders on statistical grounds. The remaining 10 variables were retained and used in all adjusted models in the dissertation work.

Table 2.3: Survey items measuring covariate variables used in adjusted models

	Variable description	Question
Age	Continuous	What is your current age in years?
Age of entry into sex work	Continuous	How old were you the first time you traded sex for money, drugs, or a place to stay? years
Average number of vaginal or anal sex clients per night	Ordinal	Thinking of the past month, what is the average number of clients that you have vaginal or anal sex with in a working day/night? a. None (only oral sex) b. One c. Two d. Three e. More than three

Current number of non-paying intimate partners	Ordinal	How many non-paying, sexual partners do you currently have? a. None b. 1 c. 2 or more
Duration of time in sex work	Ordinal	How long have you been involved in sex work? a. 6 months or less b. 6 months or more, but less than 1 year c. One year or more, but less than 2 years d. Two years or more, but less than 3 years e. Three years or more, but less than 4 years f. Four years or more
Education level	Ordinal	What is the highest level of education you have completed? a. Never attended school or have not completed primary school b. Primary education c. Secondary education d. Specialized secondary education (Diploma) e. Undergraduate education f. Higher education
Monthly salary	Continuous. Scaled to per 1,000 rubles.	In the last month, what was your current monthly salary? This includes all of your jobs, if you have multiple). rubles
Other income besides sex work	Binary	Beyond the money you earn through sex work, do you have any additional sources of income? a. Yes b. No
Relationship status	Categorical. “Legally married” and “widowed” were combined into one category due to the small number of widows and the similar outcome profile among widowed and married groups	What is your current relationship status? a. Never married b. Dating someone c. Living together as married d. Legally married e. Divorced or separated f. Widowed
Street-based sex work	Binary. 1=answers included “on the street”, 0=answered anything else and did not include “on the street”	Where are you currently working as a sex worker? (check all that apply) a. On the street b. Hotel c. Train station d. Through the internet e. Escort service f. Salon that serves clients g. Club h. Sauna i. Other (specify _____)

Missing Data

Considering the four main violence exposures and 3 outcome variables, 596 out of 754 participants had complete data, meaning complete case analysis would have dropped at least 20.9% of the sample, or 158 individuals. Single imputation or complete case analysis are simpler and generally preferred over multiple imputation when the amount of missing data is small, i.e. less than 5%, [42] while caution should be exercised in using multiple imputation when the amount of missing exceeds 30 to 50%.[43] The amount of missing data in this dataset falls neatly between these values (5 to 30-50%), making multiple imputation a reasonable approach.

Multiple imputation is a technique used to maximize use of available information and reduce bias while obtaining appropriate estimates of uncertainty.[44] Missing values are predicted using responses to other questions in the dataset, and this process is repeated multiple times (hence multiple imputation). Analytic results are summarized across datasets to obtain an unbiased estimate with appropriate error, if the imputation model meets the appropriate assumptions such as including all relevant predictors. Multiple imputation avoids dropping data that may not be missing at random as is done in complete case analysis (yielding biased estimates and lower power), and avoids inappropriately narrow uncertainty estimates and point estimates biased toward the null as is the case in mean imputation.[42]

Multiple imputation with chained equations was used to impute the majority of the missing data. Because of difficulties with model convergence due to the number of variables that needed to be imputed, variables that were missing less than 2% of values (i.e. less than or equal to 13 values missing) were imputed using the mean or mode of respondents in the same recruitment chain. The only exception is that inconsistent condom use with intimate partners was imputed using the mode among participants with the same relationship status rather than same cluster membership, as this variable was more homogenous within relationship status than within cluster. The remaining variables were imputed via multiple imputation with 20 multiply imputed datasets.

Sex work duration was a covariate in analytic models, modeled as an ordered categorical variable. Rather than imputing missing data for this variable directly (4.2% missing), missing values were calculated based on imputed age (0.7% missing) and age of entry (7.8% missing), in order to maintain consistency across the variables and reduce issues with model convergence when using ordered logistic regression in the imputation model to impute sex work duration directly. As continuous variables, age and age at entry were computationally easier to impute.

The following types of variables were included in the imputation model:

- Exposure variables
- Outcome variables
- Analytic covariates of interest (potential confounders)
- Auxiliary variables: Any variables that are associated with the primary exposure and outcome variables
- Auxiliary variables: Any variables that are associated with missingness in the primary exposure and outcome variables
- Cluster membership (i.e. recruitment chain membership)

Table 2.4: Variables included in imputation model

	Type of variable	Number missing n (%)
Multiply imputed		
Intimate partner violence	Key exposure	79 (10.4)
Client violence	Key exposure	57 (7.6)
Inconsistent condom use with clients	Key outcome	28 (3.7)
Alcohol during sex work	Auxiliary variable	20 (2.7)
Age of entry into sex work	Covariate	59 (7.8)
Police violence	Key exposure	16 (2.1)

Mean or mode imputed		
Average number of vaginal or anal sex clients per night	Covariate	13 (1.7)
Wealth	Auxiliary variable	11 (1.5)
Propiska (official documents)	Auxiliary variable	10 (1.3)
Injecting drug use	Key outcome	5 (0.7)
Age	Covariate	5 (0.7)
Monthly salary	Covariate	5 (0.7)
Russian nativity	Auxiliary variable	4 (0.5)
Education	Covariate	4 (0.5)
Other income besides sex work	Covariate	3 (0.4)
Pimp violence	Key exposure	3 (0.4)
Relationship status	Covariate	3 (0.4)
Current number of nonpaying intimate partners	Covariate	2 (0.3)
Inconsistent condom use with intimate partners	Key outcome	2 (0.3)
Street-based sex work	Covariate	2 (0.3)

Study Sample

Sample demographics are presented in Table 5. The average FSW was in her mid-twenties and had entered sex work in her early twenties. On average, FSW made 38,732 rubles (US\$685) per month and three-quarters (74.0%) relied on sex work as their only source of income. Nearly half (45.8%) of FSW had more than three clients with whom they had vaginal or anal sex per night on nights when they were working. Slightly more than half (57.2%) had at least one intimate partner. Nearly half (45.9%) had a primary education or less. Participants were overwhelmingly Russian born (92.3%), with the remainder coming from other Eastern European and Central Asian countries, but only about two-thirds (65.1%) had their documentation papers that enable access to medical care, employment, banking, and other social institutions. The most common relationship status was never married (41.6%). with the next most

common responses dating someone (19.8%) and living together as if married (19.1%). Nearly half (44%) had at least one child. Street based sex work was the most common sex work venue (65.9%), with hotel-based (32.1%), internet-based (15.3%), and escort (17.6%) services also common. Alcohol use was heavy, with 71.3% stating they use alcohol while selling sex. Nearly half currently work with a pimp, momka, agency, or tochka (45.4%), with a roughly equal number never having worked with anyone (43.9%) and the remainder (10.5%) formerly having done so.

Table 2.5: Sample Demographics

		<i>Prevalence (%)</i>
Average number of vaginal or anal sex clients per night	None (only oral sex) One Two Three More than three	4.5 7.4 23.8 18.4 45.8
Current number of non-paying intimate partners	None 1 2 or more	42.8 52.8 4.4
Duration of time in sex work	6 months or less 6 months or more, but less than 1 year One year or more, but less than 2 years Two years or more, but less than 3 years Three years or more, but less than 4 years Four years or more	5.1 7.6 15.2 20.2 12.9 38.9
Education level	Never attended school, have not completed primary school, or primary education Secondary education Specialized secondary education (Diploma) Undergraduate education Higher education	45.9 35.3 13.5 13.5 5.3
Other income besides sex work	Yes No	26.0 74.0
Nativity	Russia Kazakhstan Ukraine Other (Eastern European and Central Asia)	92.3 2.9 2.7 2.1
Propiska	Yes No	65.1 34.9
Alcohol during sex work	Yes No	71.3 28.7
Relationship status	Never married Dating someone	41.6 19.8

	Living together as married	19.1
	Legally married	4.5
	Divorced or separated	13.1
	Widowed	1.9
Number of children	Zero	56.0
	One	32.6
	Two or more	11.4
Sex work venue	On the street	65.9
	Hotel	32.1
	Train station	0.1
	Through the internet	15.3
	Escort service	17.6
	Salon that serves clients	3.2
	Club	3.3
	Sauna	1.9
	Other	24.8
Works with pimp agency, pimp, momka, or tochka	Currently	45.4
	Formerly, but now independent	10.5
	Never worked with one	43.9
		<i>Mean (range)</i>
Age	(years)	26.0 (18, 49)
Age of entry into sex work	(years)	21.6 (13, 40)
Monthly salary	(rubles)	38,732 (77, 200,000)

Data Analysis

Complex survey design procedures[45] were used to account for non-independence of participants (i.e. intraclass correlation, ICC) within the same recruitment chain using the `svy` commands in STATA13. Many participants were unable to accurately respond to the network size questions, making calculation and use of RDS weights to obtain population-based estimates inappropriate. Prevalence estimates are therefore only representative of the sample rather than the entire population of FSW. Multiple approaches exist for multivariate RDS analysis, several of which suggest not to use RDS weights in multivariate models.[45] All regressions are performed with complex survey adjustment for intraclass correlation by strata (city) and cluster (recruitment chain). This accounts for the non-independence within recruitment chains; specifically, individuals are more likely to recruit their peers who are more similar to them in their covariate and outcome values than someone randomly drawn from

the entire population of FSW. *Svy* commands were used in conjunction with *mi estimate* commands to take into account missing data using multiple imputation. Significance level α was set at 0.05 for all analyses. In aim 3, marginally significant results for interaction analyses are also reported at $p < 0.10$ due to concerns about power.

Data Analysis: Aim 1

The focus of Aim 1 was to quantify the prevalence of and the relationship between different types of violence (intimate partner violence, client violence, pimp violence, and police violence) and describe how these types of violence are distributed throughout the population.

Descriptive statistics were calculated to report the prevalence of the four types of violence and the prevalence of experiencing each violence profile (16 possible profiles from four binary exposures). To determine if certain violence profiles are experienced more or less than would be expected by chance, we calculated the expected prevalence of each violence profile if each type of violence were randomly distributed throughout the sample while maintaining the same overall prevalence (i.e. multiplying the independent probabilities of experiencing or not experiencing each type of violence), and used the Clopper-Pearson exact method[46] to determine if the observed proportion of individuals in the dataset who experience a specific violence profile significantly differ from what would be expected by chance.

Using a series of multivariate log-binomial regression models (or Poisson regression models where log-binomial models fail to converge), we evaluate if the four types of violence are associated with one another. Significant associations between the four types of violence would correspond to the concept in the polyvictimization and syndemics literatures that exposures are mutually reinforcing and that experiencing one type of violence may increase risk for other types of violence. For each of the twelve possible pairwise combinations of violence types (unlike odds ratios, relative risks are not symmetrical, necessitating the use of 12 combinations rather than 6), we build three separate models: model 1 (crude

RR without adjustment), model 2 (adjusted RR adjusted only for other types of violence), and model 3 (adjusted RR adjusted for other types of violence and demographic variables).

We then use formalized cluster analytic methods to understand how multiple different types of violence cluster in this setting. With four binary exposures, there are 16 unique profiles possible. Cluster analysis aggregates these 16 possible profiles into a smaller number of meaningful clusters. A similar approach has been used to understand polyvictimization cluster profiles in a sample of urban US African-American adolescents.[47] Cluster analysis offers additional flexibility over looking at each pairwise grouping of violence as it allows for higher-order clusters (clustering of 3 or 4 types of violence) and gives a better sense of whether there are major clusters of sex workers with different polyvictimization profiles.

We use average-linkage simple agglomerative hierarchical clustering with the four binary violence exposure measures as the cluster-defining variables to identify patterns of violence clustering.[48] Average-linkage clustering uses the unweighted pair group method with arithmetic mean (UPGMA) to determine cluster groupings. This algorithm agglomerates based on the average distance between an individual in cluster A and an individual in cluster B, and is robust and performs well even with clusters of different sizes.[49] Distance between clusters is calculated using binary distance, also known as the Jaccard dissimilarity coefficient, rather than Euclidean distance, as it is generally more appropriate for binary indicators.[50] The Jaccard coefficient between two individuals is calculated by counting the number of dissimilar exposures between the two, divided by the number of exposures experienced by at least one of them.[50]

We used a dendrogram to visualize the data and determine the number of clusters that best fit the data by balancing the desire for a relatively small number of clusters with the desire to have relatively homogeneous clusters as measured by UPGMA. One picks a dissimilarity cut point, which can be visualized by drawing a horizontal line cutting across the dendrogram. Moving this line up and down (i.e. changing the cut point) determines the number of clusters selected using that dissimilarity cutoff point. Choosing a cutoff point at the bottom of the dendrogram would choose a large number of clusters that

were maximally homogenous within cluster, while moving the line up would select a small number of clusters that will be more heterogeneous (dissimilar) within cluster. Choosing a cutoff point with a relatively large vertical distance to the next cluster bifurcation is preferred;[51] a cutoff point that is narrowly sandwiched between bifurcations would result in agglomerating two clusters with dissimilarity coefficient X but separating two clusters with a dissimilarity coefficient very close to X. The best option among those choices would depend on additional considerations such as the number of participants in each cluster, how the clusters will be used, and background knowledge of the nature of the indicators. The clustering algorithm was run on each of the 20 multiply imputed datasets and results were reported for the most commonly generated solution across the 20 datasets.

Out of the 16 victimization profiles possible with four binary violence exposures, we ultimately identified a solution with 6 clusters that best described the major victimization profiles in this sample (Solution A, Table 6). Cluster analysis was sensitive to slight variations between imputation datasets, with 5 unique clustering solutions identified depending on which imputed dataset was used to run the clustering algorithm (Table 6). This sensitivity likely reflects some very low-prevalence victimization profiles that only occurred in some imputation datasets (e.g. in several of the imputation datasets there were no individuals experiencing pimp and police violence without client and intimate partner violence), which changed the set of victimization profiles processed by the clustering algorithm. All solutions identified a “no violence” cluster, but then identified either 4 or 5 more additional clusters that varied across datasets. The greatest number of datasets (n=6) identified the following six-cluster solution, solution A (Table 6): 1) *no violence* (55.3% of the sample) 2) *client-pimp* (client violence alone, client and pimp violence, or client, intimate partner, and pimp violence, 17.3% of the sample), 3) *client-police* (client and police violence; client, police, and pimp violence, client, police, and intimate partner; or all 4 types of violence; 9.5% of the sample), 4) *IPV-client* (IPV alone or IPV and client violence; 9.0% of the sample), 5) *police violence* (police violence alone; police violence with IPV; or police violence with pimp violence; 6.4% of the sample), and 6) *pimp violence* (pimp violence alone or pimp violence with IPV, 2.4% of the sample). When presenting the results in Chapter 3, we rename “Solution A” clusters as no

violence, client violence, highly polyvictimized, IPV, police violence, and pimp violence to make the distinguishing characters more clear.

Table 2.6: Five clustering algorithm solutions yielded by different imputed datasets (N=20 datasets total).

Cluster name	Solution A N=6 datasets	Solution B N=5 datasets	Solution C N=5 datasets	Solution D N=3 datasets	Solution E N=1 dataset
No violence	No violence 55.3%	No violence 54.8%	No violence 55.3%	No violence 54.9%	No violence 55.3%
Client alone	-	-	Client alone 12.9%	-	Client alone 12.5%
Client-police	Client/police Client/police/pimp Client/police/IPV All types <i>Renamed “Highly polyvictimized cluster”</i> 9.5%	Client/police Police alone 9.5%	Client/police Police alone 8.4%	Client/police Police alone 9.2%	Client/police Client/police/pimp Client/police/IPV All types 9.5%
Client-pimp	Client/pimp Client/IPV/pimp Client alone <i>Renamed “Client” cluster</i> 17.3%	-	Client/pimp Client/IPV/pimp All types Client/police/pimp 8.9%	-	-
Client-plus	-	Client alone client/pimp, client/IPV/pimp, all types, client/police/pimp client/ipv client/police/ipv 28.2%	-	Client alone client/pimp, client/IPV/pimp, all types, client/police/pimp client/ipv client/police/ipv 28.4%	-
IPV-client	IPV alone IPV/client <i>Renamed “IPV” cluster</i> 9.0%	-	-	-	IPV alone IPV/client 9.0%
IPV plus	-	IPV alone IPV/police IPV/pimp IPV/client/police 5.4%	IPV alone IPV/police IPV/client IPV/client/police 12.1%	IPV alone IPV/police 5.0%	-
Police	Police alone Police/IPV Police/pimp	-	-	-	Police alone Police/IPV Police/IPV/pimp

	6.4%				6.4%
Pimp	Pimp alone Pimp/IPV 2.4%	Pimp alone 2.0%	Pimp alone Pimp/IPV Pimp/police 2.5%	Pimp alone Pimp/IPV Pimp/police 2.5%	Pimp alone Pimp/IPV Pimp/client Pimp/client/IPV 7.3%

Percentages show the percent of the sample belonging to that cluster. Prevalence may vary slightly by imputation dataset.

We computed the prevalence of each type of violence (client, police, intimate partner, and pimp violence) in each cluster. We then used multinomial logistic regression to determine what demographic and sex work-related variables (age, sex work venue, age of entry into sex work, etc) are associated with membership in each cluster as compared to the reference cluster that experienced no violence. Associations between demographic factors and cluster membership described who is most at-risk for common violence clusters.

A cluster analysis approach was chosen in lieu of latent class regression, which is another statistical approach that describes major clusters or “classes” within a population based on response patterns to binary indicators.[52] A key advantage of latent class regression is that it is a probability-based technique that allows for goodness-of-fit testing of models and modeling of uncertainty in assigning class membership.[52] However, with only four indicators, a latent class model with three or more classes will not be identifiable (i.e. no single best solution exists). A latent class analysis is therefore not possible unless we use additional indicators beyond the four key exposures of interest. Depending on response patterns within the data, small cell sizes can also lead to issues with estimability and lack of convergence in latent class models. A cluster analysis approach is adequate for our purposes, and was selected for its simplicity and flexibility given our four indicators of interest.

The cluster analysis ultimately yielded clusters that were not highly interpretable or distinct (see full discussion in Chapter 3). We therefore did not continue using the clusters in later chapters for further analysis.

Data Analysis: Aim 2

The goals of this analysis were 1) to establish whether each form of violence is associated with each HIV-related outcome, and 2) to understand what forms of violence have the strongest association (bivariate and adjusted) with each outcome, in order to build a holistic picture of how specific types of violence are implicated in specific HIV risk pathways. Because there are three outcomes (injecting drug use, inconsistent condom use with intimate partner, and inconsistent condom use with clients,), the same analytic steps were repeated for each outcome. First, we used cross-tabulations to understand the prevalence of each outcome among those unexposed and exposed to each type of violence. Using bivariate log-binomial regression, we then determined the unadjusted risk ratio between each of the health outcomes and each type of violence. We then built a second series of models that adjust for demographic confounders only. Finally, we used multivariate log-binomial regression, including all four violence exposures and key confounders in the model, to calculate the independent association of each type of violence for each outcome. Regression models with the outcome of inconsistent condom use with intimate partners only used FSW who reported having a current intimate partner (N=431) rather than the full sample (N=754) as only this subset was at-risk for the outcome.

Data Analysis: Aim 3

The goal of this analysis was to use dose-response and interaction analyses to evaluate the extent of a mutually enhancing synergistic relationship of polyvictimization on sexual and drug-related HIV risk. We use standard analyses in the syndemics literature (linear dose-response analysis) and apply new analyses (quadratic dose-response, multiplicative interaction, additive interaction) that may better operationalize qualitative findings and theoretical findings from the field for quantitative analyses.

Two important concepts are operationalized by the new approaches as compared to the standard linear dose-response. First, all three approaches quantitatively test for synergy, a core concept of

syndemic theory (Table 7). The linear dose-response model does not adequately operationalize synergy in an epidemiological or statistical sense, as it does not test for *excess* risk beyond the independent effects of each individual syndemic factor. Linear dose-response therefore cannot identify pairs of co-occurring exposures that exhibit a synergistic effect (beyond a proportionally additive effect) on health. The linear dose-response test only shows that there is more burden to health as the number of exposures rises.

Second, the multiplicative and additive interaction analyses also allow syndemic factors to be distinct. Using a sum score of exposures implicitly treats all syndemic factors as interchangeable. A count variable with a linear test for trend implicitly models each exposure as having a unit effect on the outcome, even though some exposures might have a larger effect than others. It also cannot identify the most important exposures or combinations of exposures to address using interventions. Taken to an extreme in the polyvictimization literature, dose-response analyses of adverse childhood experiences have implicitly treated adverse experiences as different as having parents divorce and being sexually abused as interchangeable in expected impact on health, when they are demonstrably not.[53] This lack of specificity has obscured important differences between factors within a given syndemic, diluting the ability to target interventions toward particularly potent syndemic exposures or co-occurring pairs of exposures that interact synergistically to produce excess risk.

Table 2.7: Summary of analytic methods used in Aim 3

	Number of terms required per model	Tests for synergism?	Allows factors to be distinct ?	Other pros and cons
Analyses conducted				
<i>Standard approach in the literature:</i>				
Linear dose-response $\text{Log}(Y_i) = \beta_0 + \beta_1 x$ Where x is a sum score of exposures	1	NO	NO	Simple
<i>Novel approaches applied in the dissertation:</i>				
Quadratic dose-response	2	YES	NO	Simple

$\text{Log}(Y_i) = \beta_0 + \beta_1 x_i^2 + \beta_2 x_i$ Where x is a sum score of exposures				
Pairwise multiplicative interaction $\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{1i} x_{2i}$ Where x_1 and x_2 are specific syndemic exposures	3	YES	YES	Requires many models
Pairwise additive interaction $\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{1i} x_{2i}$ $\text{RERI} = (e^{\beta_1 + \beta_2 + \beta_3} - 1) - (e^{\beta_1} - 1) - (e^{\beta_2} - 1)$ Where x_1 and x_2 are specific syndemic exposures	3	YES	YES	Requires many models
Other proposals from the literature:				
Fully saturated interaction analysis[54] $\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + \beta_5 x_{1i} x_{2i} + \beta_6 x_{1i} x_{3i} + \beta_7 x_{1i} x_{4i} + \beta_8 x_{2i} x_{3i} + \beta_9 x_{2i} x_{4i} + \beta_{10} x_{3i} x_{4i} + \beta_{11} x_{1i} x_{2i} x_{3i} + \beta_{12} x_{1i} x_{2i} x_{4i} + \beta_{13} x_{1i} x_{3i} x_{4i} + \beta_{14} x_{1i} x_{3i} x_{4i} + \beta_{15} x_{1i} x_{2i} x_{3i} x_{4i}$ Where x_1 to x_4 are specific syndemic exposures	$2^n - 1$ for n factors	YES	YES	Theoretically ideal, but requires large sample and exponential number of terms

Standard analysis: Linear dose-response

We first used a standard dose-response analysis, exploring the hypothesis that as the number of syndemic factors (i.e. types of violence) increases, the effect on health outcomes (injecting drug use, inconsistent condom use with clients, and inconsistent condom use with intimate partners) grows larger. Implicitly, this model assumes a one-unit increase in risk of the outcome for each additional type of violence experienced. Each participant was assigned a syndemic factors count variable ranging between 0 and 4 corresponding to the number of types of violence (among client, police, intimate partner, and pimp violence) they experienced. The prevalence of the health outcome was calculated among each of the 5 syndemic count tiers (0, 1, 2, 3, or 4). Using those who experienced no violence as the reference category, the risk ratio for the outcome was calculated for those who experienced 1, 2, 3, and 4 types of violence. To test for the significance of a linear trend, we also built a regression model where the syndemic count variable is modeled as continuous rather than categorical.

Three log-binomial regression models, one for each outcome, take the form:

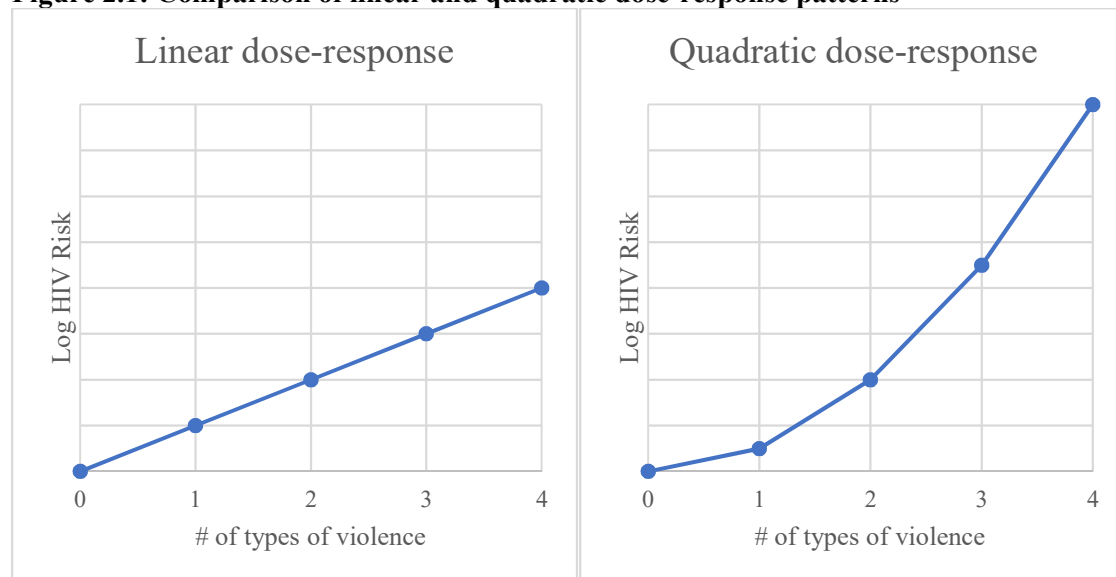
$$\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni}$$

Where Y is the probability of the HIV risk outcome of interest, w_1 through w_n represent potential confounders included in the model, and x_1 is a count variable taking the values 0, 1, 2, 3, or 4 corresponding to the number of types of violence experienced.

Synergism analysis 1: Quadratic dose-response

The quadratic model is able to capture cases where the relationship between the “dose” of violence (i.e. number of types of violence) experienced and the “response” in the risk of the outcome is curved. Whereas the standard linear dose-response analysis assumes a constant rate of change as participants experience additional forms of violence, the quadratic model indicates synergism by showing accumulation of *excess* risk at higher “doses” of violence above and beyond the risk associated with each individual form of violence happening in isolation.

Figure 2.1: Comparison of linear and quadratic dose-response patterns



We model each HIV risk outcome in multivariate Poisson regression models including the syndemic count variable, a squared syndemic count variable, and potential confounders. The significance of the quadratic regression coefficient indicates a significant quadratic dose-response relationship.[55] Significance of a quadratic term would indicate a supra-additive relationship between syndemic count and the outcome in the case of a positive quadratic coefficient (risk ratio>1), or a plateau effect at high levels

of syndemic count in the case of a negative quadratic coefficient (risk ratio <1). This would indicate positive or negative synergy, respectively.

Three log-binomial regression models, one for each outcome, take the form:

$$\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i}^2 + \beta_2 x_{1i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni}$$

Where Y is the probability of the HIV risk outcome of interest, w_1 through w_n represent potential confounders included in the model, and x_1 is a count variable taking the values 0, 1, 2, 3, or 4 corresponding to the number of types of violence experienced. This model has a quadratic term ($\beta_1 x_{1i}^2$) and a linear term ($\beta_2 x_{1i}$), whereas the standard linear dose-response above only has a linear term.

Significance of the coefficient β_1 indicates synergy.

Mathematically, the quadratic test-for-trend approach is identical to testing for multiplicative interaction, with the simplifying assumptions that 1) all types of violence have the same main effect, 2) all pairwise combinations of violence have the same interaction effect, and 3) there are no higher-order interactions.

To see this, let A, B, C, and D be binary indicator variables for the four forms of violence. Then x_1 , the count variable for number of violence exposures, can be defined as $x_1 = A+B+C+D$. Because A, B, C, and D only take value 0 or 1, then $A^2=A$, $B^2=B$, $C^2=C$, and $D^2=D$. Using these assumptions, we can re-express the quadratic and linear terms in our model, $\beta_1 x_{1i}^2 + \beta_2 x_{1i}$, in terms of the violence exposure variables A, B, C, and D:

$$\begin{aligned} \beta_1 x_{1i}^2 + \beta_2 x_{1i} &= \beta_1 (A+B+C+D)^2 + \beta_2 (A+B+C+D) \\ &= \beta_1 (A^2+B^2+C^2+D^2+2AB+2AC+2AD+2BC+2BD+2CD) + \beta_2 (A+B+C+D) \\ &= \beta_1 (A+B+C+D+2AB+2AC+2AD+2BC+2BD+2CD) + \beta_2 (A+B+C+D) \\ &= (\beta_1 + \beta_2)(A+B+C+D) + 2\beta_1 (AB+AC+AD+BC+BD+CD) \end{aligned}$$

From the final equation, we can read that the quadratic test for trend model with coefficient β_1 on the quadratic term and coefficient β_2 on the linear term is equivalent to a fully saturated interaction model

with coefficient $(\beta_1 + \beta_2)$ on each main effect, coefficient $2\beta_1$ on each pairwise interaction effect, and a 0 coefficient for all higher-order interactions.

Therefore, the quadratic dose-response test improves upon the linear dose-response test by testing mathematically for synergistic interaction. It still retains the issue that all syndemic factors are treated as interchangeable by use of a sum score of exposures (Table 7). The lack of specificity decreases interpretability for designing public health interventions that target specific combinations of factors. We propose this test, despite this limitation, because it is the simplest test possible that will actually mathematically test for synergy between syndemic factors. Previous authors have critiqued the multiplicative and additive interaction analyses proposed below for their sample size demands. Statistically significant pairwise multiplicative interaction terms require a large sample size to achieve. The sample size required may be inflated further if syndemic factors are highly collinear (as would be predicted by their mutually causal nature), making pairwise multiplicative and additive interaction analyses a difficult and potentially unfairly high bar to clear to demonstrate synergism and resulting in Type II error.[54, 56] The quadratic dose-response test reduces the demands on sample size by use of strong simplifying assumptions that all syndemic factors have the same main effect and all pairwise combinations of factors have the same interaction effect. This makes the quadratic dose-response test a simple and feasible option to mathematically test for synergism in small to moderately sized samples.

Synergism analysis 2: Multiplicative interaction

Multiplicative interactive occurs if factor A is associated with an X times increase in risk of the outcome, factor B is associated with a Y times increase in risk of the outcome, and individuals who experience both factor A and factor B exhibit significantly greater than a $X*Y$ times increase in risk of the outcome as compared to individuals who experience neither factor A nor factor B.[57] In log-binomial and Poisson regression models, this can be ascertained using a product term between factor A and factor B. Because there are three outcomes (injecting drug use, inconsistent condom use with intimate partner, and inconsistent condom use with clients), and six possible pairwise combinations of the four types of

violence, we run 6 models for each of the 3 outcomes to understand the extent of multiplicative interaction between different types of violence in driving HIV risk outcomes.

We include in each model 1) two binary exposure variables for two types of violence, 2) a multiplicative interaction term between those two types of violence, and 3) demographic confounders. A significant interaction coefficient indicates a significant interaction effect on the multiplicative scale.

For each of the three outcomes, six log-binomial regression models (one for each pairwise combination of violence exposures) test for interaction:

$$\begin{aligned} \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3^* x_{1i}^* x_{2i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\ \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{1i} + \beta_2 x_{3i} + \beta_3^* x_{1i}^* x_{3i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\ \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{1i} + \beta_2 x_{4i} + \beta_3^* x_{1i}^* x_{4i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\ \text{Log}(Y_i) &= \beta_0 + \beta_2 x_{1i} + \beta_2 x_{3i} + \beta_3^* x_{2i}^* x_{3i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\ \text{Log}(Y_i) &= \beta_0 + \beta_2 x_{1i} + \beta_2 x_{4i} + \beta_3^* x_{2i}^* x_{4i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\ \text{Log}(Y_i) &= \beta_0 + \beta_3 x_{1i} + \beta_2 x_{4i} + \beta_3^* x_{3i}^* x_{4i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \end{aligned}$$

Where Y represents the probability of the HIV risk outcome, x_1 through x_4 represent different types of violence exposures, and w_1 through w_n represent potential confounders included in the model. A significant interaction coefficient, β_5 through β_{10} , indicates a significant interaction effect on the multiplicative scale. Poisson regression was used where log-binomial models did not converge.

Unlike the linear or quadratic dose-response approaches, this approach allows us to look at an interaction effect between two specific types of violence while adjusting for exposure to confounders. Significance of the interaction term indicates a multiplicative synergistic effect of experiencing both types of violence on our outcomes, above and beyond the independent effect of each type of violence. This analysis also allows identification of specific pairings of violence that produce this synergistic effect.

We do not adjust for other types of violence besides the two main violence exposures in each model; for instance, the model testing multiplicative interaction between police and client violence does not also adjust for pimp violence or IPV. Adjusting for a third type of violence may underestimate the total effect of the main types of violence on the outcome if the third type of violence is a mediator on the causal pathway between the main types of violence and the outcome (see Aim 2 for a fuller discussion).

Statistically, this approach also conserves power. However, this approach may not fully control for confounding between all types of violence.

Regression models with the outcome of inconsistent condom use with intimate partners only used FSW who reported having a current intimate partner (N=431) rather than the full sample (N=754) as only this subset was at-risk for the outcome.

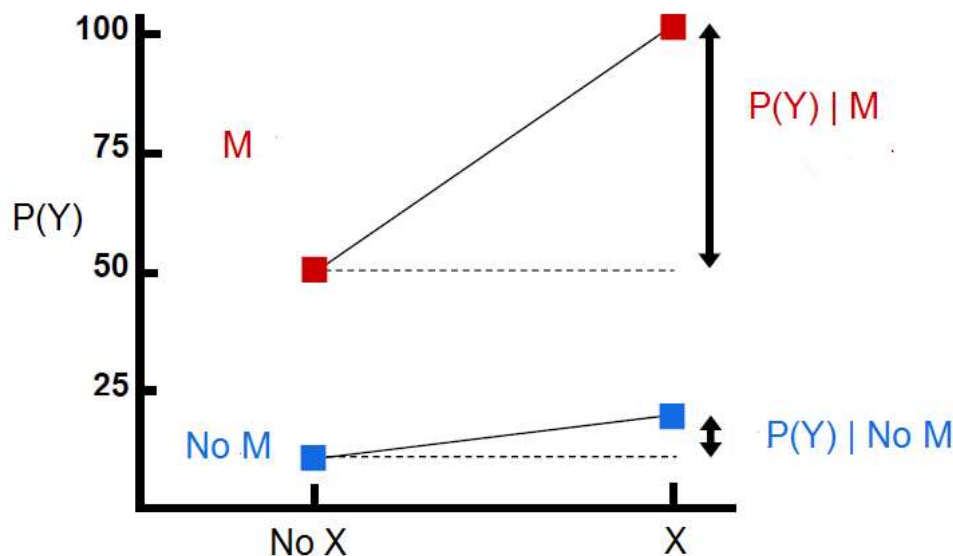
Synergism analysis 3: Additive interaction

Statistical techniques for understanding interaction effects were first developed to study biological interaction, particularly gene-environment interaction studies where the effect of an environmental variable is only significant in the presence of a specific allele. Multiplicative interaction terms, constructed by multiplying two covariates together as a separate term in a regression model, are sufficient to study these relatively straightforward interactions, where an effect is either “on” or “off” depending on the presence of the gene. However, detection of interaction effects in epidemiologic or population samples, rather than in biologic processes, has been a subject of much debate.[58]

Some researchers assert that an additive, rather than a multiplicative, interaction effect may be of more interest from a public health standpoint.[55, 59-61] Additive interaction occurs if factor A is associated with X percentage points of increase in risk of the outcome, factor B is associated with Y percentage points of increase in risk of the outcome, and individuals who experience both factor A and factor B exhibit significantly greater than X+Y percentage points greater risk of the outcome than individuals who experience neither factor A nor factor B.[57] For instance, in Figure 5, let Y be the outcome of interest, X be the exposure of interest, and M be an effect modifier. We are interested in whether M interacts with X, and produces effect modification on the $X \rightarrow Y$ relationship. On a multiplicative scale, there is no effect modification by M, because X is associated with a 2 times increased probability of the outcome both in the presence of M and in the absence of M. On an additive scale, X results in a 50 percentage point increase in the probability in the presence of M, but only 10 percentage point increase in the probability of Y in the absence of M. From a public health perspective,

we may be very interested in knowing that in the presence of M, the outcome reaches 100% probability, while in the absence of M, the outcome reaches only 20% probability, and that there is much more additional risk conferred by X in the presence of M (50 percentage points versus 10 percentage points). For populations experiencing X in the presence of M, the case load and public health burden will be much higher. Additive interaction therefore may “take precedence” over multiplicative interaction in identifying high-risk groups to target for interventions.[55] However, depending on the exposures and outcome of interest, multiplicative interaction may still of interest from a causal or theoretical standpoint, rather than a practice-oriented standpoint.[58]

Figure 2.2: Illustration of additive versus multiplicative interaction. Adapted from Epi752, Lecture 19, JHSPH, 2012.



This example highlights the issue of *scale dependence* when studying interaction. There may be interaction on the additive scale, but not the multiplicative scale, or vice versa. It is possible to have a positive interaction on the additive scale but a negative interaction on the multiplicative scale simultaneously.[55] Rothman et al state, “when two factors have an effect, risk-ratio homogeneity – though often misinterpreted as indicating absence of biologic interaction – implies just the opposite, that

is, *presence* of biologic interactions...homogeneity of a ratio measure implies heterogeneity (and hence nonadditivity) of the corresponding difference measure. This nonadditivity in turn implies the presence of some type of biologic interaction.”[58] Given that little is known about how specific forms of violence actually interact in a syndemic context, it is unclear whether a multiplicative or additive interaction effect is most appropriate. Existing qualitative and theoretical work does not uniformly point to either multiplicative or additive interaction. Therefore, we are interested in investigating interaction on both the additive scale and the multiplicative scale.

Presenting both additive and multiplicative interaction analyses is also consistent with best practices for presenting interaction effects.[61] Knol and VanderWeele suggest presenting the following information for optimal transparency in interaction analyses of exposures A and B: 1) ARR for the effect of exposure A on the outcome and the effect of exposure B on the outcome, 2) ARR of the effect of exposure A on the outcome within the stratum of individuals experiencing exposure B, and ARR of the effect of exposure B on the outcome within the stratum of individuals experiencing exposure A, 3) both additive and multiplicative measures of interaction, and 4) the confounders adjusted for in regression models. Item 1 is presented in Aim 2, while items 2 and 3 are presented in Aim 3.

When using a log-binomial regression model, additive interaction effects must be estimated using techniques such as the relative excess risk due to interaction (RERI), attributable proportion due to interaction (AP), or synergy index (SI).[60] The synergy index is preferred over the RERI and the AP in the multivariate setting because it provides a unique measure of interaction in the presence of covariates, [60] but it should also only be used if the doubly unexposed group has the lowest absolute risk of the outcome.[61] Because this was not true for all violence and outcome combinations, we present the RERI. See Methods Appendix for an illustrative example of how RERI is calculated.

For a given model

$$\text{Log}(Y_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 * X_{1i} * X_{2i} + \gamma_1 W_{1i} + \dots + \gamma_n W_{ni}$$

The RERI is calculated by [57]:

$$RERI = (e^{\beta_1 + \beta_2 + \beta_3} - 1) - (e^{\beta_1} - 1) - (e^{\beta_2} - 1) = (RR_{11} - 1) - (RR_{10} - 1) - (RR_{01} - 1) = RR_{11} - RR_{10} - RR_{01} + 1$$

This quantity represents the excess risk of the doubly exposed group ($RR_{11}-1$) minus the excess risk from the singly exposed groups ($RR_{10}-1$ and $RR_{01}-1$), where β_{10} is the coefficient for the relative risk of the outcome associated with experiencing violence type 1, β_{01} is the coefficient for the relative risk of the outcome associated with experiencing violence type 2, and β_{11} is the coefficient for the relative risk of the outcome associated with the interaction between experiencing both types of violence.

The RERI can be interpreted as the increase in the relative risk of the outcome from exposure to both exposures, above and beyond the sum of the independent effects. A $RERI > 0$ indicates positive additive interaction, while a $RERI < 0$ indicates negative additive interaction. The same models used to calculate multiplicative interaction above were used to calculate the RERI as well. For each of the 3 outcomes, we calculate the RERI for each pairwise combination of violence using the same 6 models developed in the multiplicative interaction analyses, one for each pairwise combination of violence. Looking across the models allows a holistic understanding of whether specific pairwise combinations of violence interact on the multiplicative or additive scales to synergistically produce excess HIV risk in the population.

Ethical considerations

Data collection and analysis procedures align with WHO ethical and safety guidelines for research on gender-based violence.[62]

Measures to protect confidentiality

Privacy risks included disclosure of participants' sexual practices, sex work, or HIV status. No personal identifiers were collected. RDS recruitment was chosen in part to minimize breaches to confidentiality by having peers recruit one another discreetly, rather than having study staff approach potential participants in public places where their participation in the study may be noted by others.

Confidentiality was maintained for all participants by using unique identifiers rather than real names on samples and questionnaires, protecting all data with passwords on the computer during data entry phases, and storing any hard copies under lock and key. Electronic surveys and were sent to Johns Hopkins through Datstat Illume, a secure server used for public health research. All data are stored on password-protected computers in password-protected files only accessible by study staff. There were no known breaches of confidentiality.

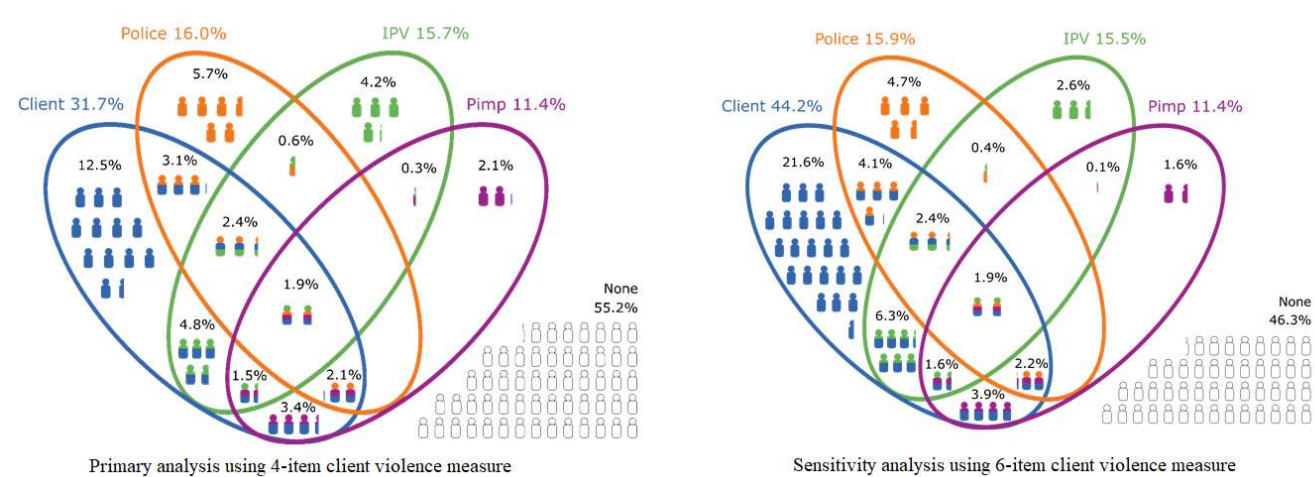
Ethical Approval

The thesis research is a secondary data analysis of an existing dataset. There was no further data collection. All data being analyzed were collected anonymously by local NGO staff during an evaluation of the Open Health Institute's GLOBUS HIV prevention program for sex workers. The current secondary analysis of existing, de-linked, deidentified data was considered not human subjects research by the JHSPH IRB.

The parent study was reviewed by the JHSPH Institutional Review Board (IRB) and approved as Public Health Practice, under Exemption 5. The exemption covers research and demonstration projects related to program evaluation. This exemption was determined by the JHSPH IRB, as the primary objective of the study was to evaluate HIV service programs. Additionally, the parent study was reviewed by the Russian non-governmental organization Open Health Institute (OHI), who also deemed it program evaluation and public health practice.

Appendix

Figure 2.A1: Prevalence of and intersections between the four types of violence using the 4-item definition of client violence and the 6-item definition of client violence.



Prevalence of police and intimate partner violence vary slightly due to different imputation results in the final version and the sensitivity analysis.

Illustrative example of RERI

Consider the following dataset:

Table 2.8. RERI calculation example

Response pattern	Prevalence of the outcome	Relative risk
00	10%	(ref)
01	20%	2.0
10	15%	1.5
11	30%	3.0

Because response pattern 01 is associated with 10 percentage points increase in the outcome and pattern 10 is associated with 5 percentage points increase in the outcome on the additive scale, with no additive interaction we would expect a 10+5=15 percentage points increase in the prevalence of the outcome, or 25% prevalence in the 11 group. This would be an expected relative risk of 2.5 in the 11

group. However, we observe a 30% prevalence. Because this is greater than 25%, we know there is positive additive interaction.

The RERI is $3 - 1.5 - 2 + 1 = 0.5$. As expected, $0.5 > 0$, indicating positive additive interaction.

Calculated another way, the observed RR for the 11 group is 3.0, which is 0.5 greater than the expected RR of 2.5, hence a RERI of 0.5.

Stated again, on the additive scale the relative risk for the doubly exposed group is 0.5 greater than expected given the sum of the independent effects for the singly exposed groups.

References

1. Decker MR, Wirtz AL, Moguilnyi V, Peryshkina A, Ostrovskaya M, Nikita M, et al. Female sex workers in three cities in Russia: HIV prevalence, risk factors and experience with targeted HIV prevention. *AIDS and behavior*. 2014;18(3):562-72.
2. United States Department of State. International Narcotics Control Strategy Report. 2014.
3. Heckathorn DD. Respondent-driven sampling: a new approach to the study of hidden populations. *Social problems*. 1997;174-99.
4. Straus MA, Hamby SL, Boney-McCoy S, Sugarman DB. The revised conflict tactics scales (CTS2) development and preliminary psychometric data. *Journal of family issues*. 1996;17(3):283-316.
5. Ellsberg M, Heise L, Pena R, Agurto S, Winkvist A. Researching domestic violence against women: methodological and ethical considerations. *Studies in family planning*. 2001;32(1):1-16.
6. Carlson CE, Chen J, Chang M, Batsukh A, Toivgo A, Riedel M, et al. Reducing Intimate and Paying Partner Violence Against Women Who Exchange Sex in Mongolia Results From a Randomized Clinical Trial. *Journal of interpersonal violence*. 2012;27(10):1911-31.
7. Gupta J, Reed E, Kershaw T, Blankenship KM. History of sex trafficking, recent experiences of violence, and HIV vulnerability among female sex workers in coastal Andhra Pradesh, India. *International Journal of Gynecology & Obstetrics*. 2011;114(2):101-5.
8. Shannon K, Strathdee SA, Goldenberg SM, Duff P, Mwangi P, Rusakova M, et al. Global epidemiology of HIV among female sex workers: influence of structural determinants. *The Lancet*. 2015;385(9962):55-71.
9. Beattie TS, Bhattacharjee P, Ramesh B, Gurnani V, Anthony J, Isac S, et al. Violence against female sex workers in Karnataka state, south India: impact on health, and reductions in violence following an intervention program. *BMC public health*. 2010;10(1):476.
10. Reza-Paul S, Lorway R, O'Brien N, Lazarus L, Jain J, Bhagya M, et al. Sex worker-led structural interventions in India: a case study on addressing violence in HIV prevention through the Ashodaya Samithi collective in Mysore. *The Indian journal of medical research*. 2012;135(1):98.
11. Decker MR, Pearson E, Illangasekare SL, Clark E, Sherman SG. Violence against women in sex work and HIV risk implications differ qualitatively by perpetrator. *BMC public health*. 2013;13(1):876.
12. Ratinthorn A, Meleis A, Sindhu S. Trapped in circle of threats: violence against sex workers in Thailand. *Health care for women international*. 2009;30(3):249-69.
13. Shannon K, Strathdee SA, Shoveller J, Rusch M, Kerr T, Tyndall MW. Structural and environmental barriers to condom use negotiation with clients among female sex workers: implications for HIV-prevention strategies and policy. *American journal of public health*. 2009;99(4):659.

14. Earausquin JT, Reed E, Blankenship KM. Police-related experiences and HIV risk among female sex workers in Andhra Pradesh, India. *Journal of Infectious Diseases*. 2011;204(suppl 5):S1223-S8.
15. Shannon K, Csete J. Violence, condom negotiation, and HIV/STI risk among sex workers. *JAMA*. 2010;304(5):573-4.
16. Kenya FIDA. Documenting human rights violations of sex workers in Kenya. Nairobi: Open Society Foundation, 2008.
17. Crago A. Arrest the violence: Human rights abuses against sex workers in Eastern Europe and Central Asia. Sex Workers' Rights Advocacy network (SWAn). 2009.
18. Decker MR, Crago A-L, Chu SK, Sherman SG, Seshu MS, Buthelezi K, et al. Human rights violations against sex workers: burden and effect on HIV. *The Lancet*. 2014.
19. Ellsberg M, Arango DJ, Morton M, Gennari F, Kiplesund S, Contreras M, et al. Prevention of violence against women and girls: what does the evidence say? *The Lancet*. 2014.
20. Decker MR, Wirtz AL, Baral SD, Peryshkina A, Mogilnyi V, Weber RA, et al. Injection drug use, sexual risk, violence and STI/HIV among Moscow female sex workers. *Sexually transmitted infections*. 2012;88(4):278-83.
21. Odinokova V, Rusakova M, Urada LA, Silverman JG, Raj A. Police sexual coercion and its association with risky sex work and substance use behaviors among female sex workers in St. Petersburg and Orenburg, Russia. *International Journal of Drug Policy*. 2014;25(1):96-104.
22. Wirtz A, Peryshkina A, Moguilnyi V, Beyrer C, Decker M. Current and recent drug use intensifies sexual and structural HIV risk outcomes among female sex workers in the Russian Federation. *International Journal of Drug Policy*. 2015.
23. Napper LE, Fisher DG, Reynolds GL, Johnson ME. HIV risk behavior self-report reliability at different recall periods. *AIDS and Behavior*. 2010;14(1):152-61.
24. UNAIDS. Global AIDS response progress reporting 2014: construction of core indicators for monitoring the 2011 UN political declaration on HIV/AIDS. 2014.
25. Deering KN, Bhattacharjee P, Bradley J, Moses SS, Shannon K, Shaw SY, et al. Condom use within non-commercial partnerships of female sex workers in southern India. *BMC public health*. 2011;11(Suppl 6):S11.
26. Murray L, Moreno L, Rosario S, Ellen J, Sweat M, Kerrigan D. The role of relationship intimacy in consistent condom use among female sex workers and their regular paying partners in the Dominican Republic. *AIDS and Behavior*. 2007;11(3):463-70.
27. Voeten H, Egesah O, Varkevisser C, Habbema J. Female sex workers and unsafe sex in urban and rural Nyanza, Kenya: regular partners may contribute more to HIV transmission than clients. *Tropical Medicine & International Health*. 2007;12(2):174-82.
28. Panchanadeswaran S, Johnson SC, Sivaram S, Srikrishnan AK, Latkin C, Bentley ME, et al. Intimate partner violence is as important as client violence in increasing street-based female sex workers' vulnerability to HIV in India. *International Journal of Drug Policy*. 2008;19(2):106-12.
29. Peitzmeier S, Mason K, Ceesay N, Diouf D, Drame F, Loum J, et al. A cross-sectional evaluation of the prevalence and associations of HIV among female sex workers in the Gambia. *International journal of STD & AIDS*. 2013;0956462413498858.
30. Su S, Li X, Zhang L, Lin D, Zhang C, Zhou Y. Age group differences in HIV risk and mental health problems among female sex workers in Southwest China. *AIDS care*. 2014;26(8):1019-26.
31. Sarkar K, Bal B, Mukherjee R, Saha MK, Chakraborty S, Niyogi SK, et al. Young age is a risk factor for HIV among female sex workers—an experience from India. *Journal of Infection*. 2006;53(4):255-9.
32. Argento E, Muldoon KA, Duff P, Simo A, Deering KN, Shannon K. High prevalence and partner correlates of physical and sexual violence by intimate partners among street and off-street sex workers. *PloS one*. 2014;9(7):e102129.
33. El-Bassel N, Witte SS, Wada T, Gilbert L, Wallace J. Correlates of partner violence among female street-based sex workers: substance abuse, history of childhood abuse, and HIV risks. *AIDS patient care and STDs*. 2001;15(1):41-51.

34. Shannon K, Rusch M, Shoveller J, Alexson D, Gibson K, Tyndall MW. Mapping violence and policing as an environmental–structural barrier to health service and syringe availability among substance-using women in street-level sex work. *International Journal of Drug Policy*. 2008;19(2):140-7.
35. Dandona R, Dandona L, Gutierrez JP, Kumar AG, McPherson S, Samuels F, et al. High risk of HIV in non-brothel based female sex workers in India. *BMC Public Health*. 2005;5(1):87.
36. Hong Y, Zhang C, Li X, Liu W, Zhou Y. Partner violence and psychosocial distress among female sex workers in China. *PloS one*. 2013;8(4):e62290.
37. Goldenberg SM, Rangel G, Vera A, Patterson TL, Abramovitz D, Silverman JG, et al. Exploring the impact of underage sex work among female sex workers in two Mexico–US border cities. *AIDS and Behavior*. 2012;16(4):969-81.
38. Lang DL, Salazar LF, DiClemente RJ, Markosyan K. Gender based violence as a risk factor for HIV-associated risk behaviors among female sex workers in Armenia. *AIDS and Behavior*. 2013;17(2):551-8.
39. Karandikar S, Gezinski LB. Intimate partner violence and HIV risks among female sex workers of Mumbai, India. *Journal of Ethnic And Cultural Diversity in Social Work*. 2013;22(2):112-28.
40. Weine S, Golobof A, Bahromov M, Kashuba A, Kalandarov T, Jonbekov J, et al. Female migrant sex workers in Moscow: gender and power factors and HIV risk. *Women & health*. 2013;53(1):56-73.
41. Pack AP, L'Engle K, Mwarogo P, Kingola N. Intimate partner violence against female sex workers in Mombasa, Kenya. *Culture, health & sexuality*. 2014;16(3):217-30.
42. Schafer JL. Multiple imputation: a primer. *Statistical methods in medical research*. 1999;8(1):3-15.
43. White IR, Royston P, Wood AM. Multiple imputation using chained equations: issues and guidance for practice. *Statistics in medicine*. 2011;30(4):377-99.
44. Education UIfDRa. Multiple Imputation in STATA 2017. Available from: http://stats.idre.ucla.edu/stata/seminars/mi_in_stata_pt1_new/.
45. Szwarcwald CL, de Souza Júnior PRB, Damacena GN, Junior AB, Kendall C. Analysis of data collected by RDS among sex workers in 10 Brazilian cities, 2009: estimation of the prevalence of HIV, variance, and design effect. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2011;57:S129-S35.
46. Clopper CJ, Pearson ES. The use of confidence or fiducial limits illustrated in the case of the binomial. *Biometrika*. 1934;26(4):404-13.
47. Kennedy AC, Bybee D, Kulkarni SJ, Archer G. Sexual Victimization and Family Violence Among Urban African American Adolescent Women Do Violence Cluster Profiles Predict Partner Violence Victimization and Sex Trade Exposure? *Violence against women*. 2012;18(11):1319-38.
48. STATA. Cluster - Introduction to cluster-analysis commands.
49. Kaufman L, Rousseeuw PJ. Finding groups in data: an introduction to cluster analysis: John Wiley & Sons; 2009.
50. Greenacre M, Primicerio R. Multivariate analysis of ecological data: Fundacion BBVA; 2014.
51. Hastie T, Tibshirani R, Friedman J. The elements of statistical learning 2nd edition. New York: Springer; 2009. p. 521.
52. Collins LM, Lanza ST. Latent class and latent transition analysis: With applications in the social, behavioral, and health sciences: John Wiley & Sons; 2013.
53. Finkelhor D, Shattuck A, Turner H, Hamby S. Improving the adverse childhood experiences study scale. *JAMA pediatrics*. 2013;167(1):70-5.
54. Tsai AC, Venkataramani AS. Syndemics and health disparities: a methodological note. *AIDS and Behavior*. 2016;20(2):423-30.
55. Szklo M, Nieto FJ. Epidemiology: beyond the basics: Jones & Bartlett Publishers; 2012.
56. Tsai AC, Burns BF. Syndemics of psychosocial problems and HIV risk: a systematic review of empirical tests of the disease interaction concept. *Social Science & Medicine*. 2015;139:26-35.
57. VanderWeele T. Explanation in causal inference: methods for mediation and interaction: Oxford University Press; 2015.

58. Rothman KJ, Greenland S, Lash TL. Modern epidemiology: Lippincott Williams & Wilkins; 2008.
59. Bauer GR. Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity. *Social science & medicine*. 2014;110:10-7.
60. Skrdal A. Interaction as departure from additivity in case-control studies: a cautionary note. *American Journal of Epidemiology*. 2003;158(3):251-8.
61. Knol MJ, VanderWeele TJ. Recommendations for presenting analyses of effect modification and interaction. *International journal of epidemiology*. 2012;41(2):514-20.
62. World Health Organization. Putting women first: ethical and safety recommendations for research on domestic violence against women. 2001.

3. Intimate partner, police, and pimp violence cluster with client violence in a sample of Russian sex workers

Abstract

Background: Female sex workers (FSW) are a key population in the HIV epidemic and in many settings face high levels of violence. While women globally are predominantly at risk of intimate partner violence (IPV), FSW are additionally vulnerable to violence from clients, police, and pimps due to their occupation. FSW are therefore at risk of polyvictimization, or experiencing more than one type of violence. Polyvictimization is a driver of morbidity and mortality in numerous populations, and in FSW violence is known to be a key driver of HIV risk, but little effort has been put into understanding patterns of polyvictimization in FSW.

Methods: We examine data from a cross-sectional survey of 754 FSW from Russia and their reported lifetime experiences of client, police, intimate partner, and pimp violence. Multivariate log-binomial and Poisson regression is used to test associations between lifetime client, police, intimate partner, and pimp violence exposure. Cluster analysis is used to group FSW into clusters by their violence exposure profile, and multinomial logistic regression is used to explore how demographic factors are associated with cluster membership.

Results: Lifetime violence is prevalent, with 44.8% experiencing any type of violence, including 31.7% from clients, 16.0% from police, 15.7% from intimate partners, and 11.4% from pimps. One-fifth (20.4%) of participants experienced two or more types (i.e. polyvictimization). In this population, client violence is central to polyvictimization: only 5.9% of polyvictimization occurs without client violence. Police, pimp, or intimate partner violence co-occur less than would be expected by chance when client violence is not present ($p < 0.001$), but co-occur more than would be expected by chance when client violence is present. After adjusting for other types of violence and demographic factors, experiencing client violence is independently associated with police violence (ARR=2.77, 95% CI 1.67, 4.59), IPV (ARR=3.67, 95%

CI 1.95, 6.89), and pimp violence (ARR=5.26, 95% CI 2.80, 9.86). Client violence is more strongly associated with IPV, pimp violence, and police violence than nearly any other demographic or sex work context variable measured.

Conclusions: Client violence may drive exposure to other types of violence and enable polyvictimization in a way that other types of violence do not. Violence prevention interventions may be able to achieve maximal effect in reducing multiple types of violence by focusing on client violence.

Introduction

Sex workers globally are at high risk of violence[1] and HIV.[2] Early HIV prevention interventions focused on individual-level factors, such as promotion of condom use, needle exchange programs, and HIV testing. More recently, violence and coercion are emerging as key structural features in the broader living and working risk environments of female sex workers (FSW) and injecting drug users (IDU).[3, 4] Violence is a structural driver of both sexual and drug-related HIV risk, as it impinges upon the ability to practice safer sex[3] and may lead to injecting drug use[5] as a coping mechanism for trauma. Women globally are most at risk of physical and sexual violence from intimate partners,[6] but FSWs face violence not just from intimate partners[7-14] but additionally from clients,[5, 7, 11, 15-21] pimps,[21, 22] and police [7, 15-18, 23, 24] in the course of their work.

Polyvictimization, defined as experiencing multiple different types of violence, crime, abuse, or victimization, is a concept that arose in the field of child abuse research. Tools from polyvictimization research have been underutilized to study exposures to multiple types of violence in adulthood and among FSW. Studying a single type of violence is problematic when other co-occurring types of violence may contribute to negative health outcomes, because it fails to take into account other relevant violence exposures driving health risk.[25] The ground-breaking Adverse Childhood Experiences (ACE) study used a dose-response framework to show that as the number of ACEs accumulated, the risk of myriad

health problems in adulthood dramatically increased.[26] Experiencing one type of violence is a risk factor for experiencing other types of violence, leading to a clustering of violence in individuals and an increasing cumulative burden on health. For instance, children who experience physical assault are five times more likely to have been sexually assaulted, 4 times more likely to have been maltreated, and 2.5 times more likely to witness violence.[27] Few surveys of FSW assess multiple types of violence and tend to study either a single type of violence (usually client violence) or from “any” unspecified perpetrator.[28] Also, because the focus is generally on how a type of violence is associated with an HIV-related outcome, relatively few papers assess associations between types of violence or seek to understand how they cluster. Here we apply a polyvictimization framework to a high-risk adult population, specifically FSW, in order to develop a comprehensive understanding of violence victimization experiences in this population. In this analysis, we seek to quantify the prevalence of polyvictimization in a sample of Russian FSW and to describe and quantify the relationship between different types of violence (intimate partner violence, client violence, pimp violence, and police violence).

We define violence types by perpetrator rather than classifying as physical, sexual, or psychological because disaggregating violence by perpetrator type is critical for designing violence and HIV prevention interventions. Violence from one type of perpetrator requires different interventions than violence from another type of perpetrator. For example, interventions to reduce client violence may include structural changes to sex work venues such as requiring client sign-in, emergency call buttons, and supportive managerial policies and crisis response,[29] while interventions to reduce police violence may involve training police, policy advocacy to change laws allowing condoms as evidence of sex work, and facilitating sex worker-police partnerships.[30, 31] Additionally, violence from each of these sources is qualitatively different in intensity, context, risk factors, and implications for HIV. For instance, sexual violence from clients often involves pressure to perform higher-risk sexual acts, such as anal or unprotected sex, or sex with multiple clients at the same time.[22, 32, 33] In contrast, police violence is linked to HIV risk via direct exposure to unprotected sexual violence, harassment and seizure of condoms or syringes as evidence,[17] aggressive policing practices that lead sex workers to move to more

clandestine locations where they may be forced to take riskier or more violent clients,[17, 33, 34] and arrest and placement in high-risk detention centers where needle sharing and further violence are common.[1, 35, 36] This focus on perpetrator-specific violence and interventions matches an overall shift in the violence research field to broaden its focus from interventions that provide services to survivors of violence to primary prevention of violence.[37] Recent evidence from a systematic review has shown that interventions that attempt to protect potential victims from abuse have limited success at reducing victimization, and that primary prevention interventions should focus on potential perpetrators.[37]

Methods

Study Setting

Russia is a unique and complex setting for understanding violence and HIV in the context of sex work. Russia is one of just a few countries in the world where HIV prevalence and incidence are still increasing.[38-41] Russia has the highest incidence in Europe; incident infections have risen on average almost 11% per year in the last decade, rising from 39,402 infections in 2005 to 98,177 in 2015.[42] Russia is transitioning toward a heterosexual contact-driven HIV epidemic from an injecting drug use-driven epidemic, particularly among women. In 2008, 63% of incident infections among women were due to sexual contact,[43] a number that may be increasing through time: Only 18.7% of prevalent infections among women in 2015 were due to injecting drug use.[41] Since 2012, foreign and multilateral donors have left or been ejected from the country, and the Russian government has not funded FSW-focused programs.[44] Injecting drug use is common among Russian FSW, with estimates including 17.7% lifetime use in Moscow[16] and 47.5% past-day use in St. Petersburg and Orenburg.[45] Recent research demonstrates prevalent physical and sexual violence against FSW.[16, 21, 45] Sex work is criminalized in Russia and punishable by a fine of 2000 rubles (\$60) while drug use is punishable with punitive detoxification programs, fines, or imprisonment.[46] HIV is prevalent among FSW, particularly in those who inject drugs. In the parent study, prevalence was 6.4%, 3.6%, and 1.6% in Kazan, Krasnoyarsk, and Tomsk, respectively, or 3.9% overall.[21] Earlier estimates from other cities showed an HIV prevalence

among FSW ranging from 4.8% in Moscow[16] in 2005 to 48.1% among FSW who inject drugs in St. Petersburg in 2003.[47] The Russian government does not provide nationwide, FSW-specific surveillance figures. [41]

Kazan is the eighth largest city in Russia and is 500 miles east of Moscow. Tomsk and Krasnoyarsk are located in Siberia. Tomsk (population 524,669) is the smallest, least industrial site and boasts several universities. Krasnoyarsk (population 1,035,528) is an industrial center located along the Trans-Siberian railway; historically Krasnoyarsk was the site of a gulag forced labor camp. All cities have significant sex work industries. Women typically recruit clients on the street, in saunas, hotels, online, or from *tochkas* (areas along streets where sex workers gather and meet clients out of cars). The number of sex workers in Russia is thought to be steadily on the rise due to economic pressures, including globalization, increasing unemployment, migration from rural to urban areas in search of work, and continuing ripples felt from the massive economic transition after the fall of the Soviet Union and from the recent financial crisis.[48]

Data collection

Data were collected in 2011 from a sample of n=754 FSW from Tomsk, Kazan, and Krasnoyarsk, Russia as part of a large-scale program evaluation for Global Fund program activities, Global Efforts Against HIV/AIDS in Russia (GLOBUS).[21] The primary objective was to evaluate GLOBUS by assessing program coverage, HIV knowledge, risk behaviors, condom use, and HIV prevalence among FSW. The survey collected detailed data on sex work context, including exposure to violence.

Formative research and survey development

Extensive qualitative formative research using in-depth interviews and focus groups with FSWs and service providers informed survey development and implementation.[21] This formative phase

confirmed that clients, intimate partners, pimps and *momkas* (female pimps), and police are substantive sources of violence in this population.

Information from the formative phase was used to develop the survey questions. The survey was developed in English, translated into Russian, and piloted by NGO staff and adjusted before implementation.

Study recruitment and eligibility

Recruitment was via respondent-driven sampling (RDS)[49] at each site, with respondents given 5 recruitment coupons each. RDS was chosen due to the difficulty of creating a sampling frame and using random sampling in a hard-to-reach population.[49] Individuals were eligible for the study if they were non-transgender women, at least 18 years old, worked or resided in one of the three cities, and had exchanged sex for money, drugs, or shelter in the past 3 months. Seeds were purposively selected by local partners to maximize diversity, including street and off-street sex work and injecting and non-injecting FSW. Study interviewers were local Russian non-governmental organization (NGO) staff trained by Johns Hopkins University staff. Interviews in Tomsk and Krasnoyarsk took place in the local NGO's office; in Kazan interviews were also conducted in a mobile unit at locations across the city due to the remoteness of the local office. Verbal consent was used to protect confidentiality. Interviews were self-administered on a computer and took 20-30 minutes, followed by OraQuick HIV testing. Women received a small gift (<\$5USD) for participation; secondary incentives were not given for recruitment of peers. The study was approved by Open Health Institute in Moscow, Russia and considered exempt as public health practice by the Johns Hopkins School of Public Health Institutional Review Board; the current secondary analysis of existing, de-linked, deidentified data was considered not human subjects research by the same IRB. Further details are published elsewhere.[21]

Exposure measures: violence from intimate partners, clients, pimps and police.

The violence exposures are lifetime exposure to intimate partner violence (physical), client violence (physical or sexual), pimp/momka violence (physical or sexual), and police violence (sexual) (See Table 1). Extensive formative research identified these types of violence as most relevant in the lives of FSW in this setting. Measures are based on the Conflicts Tactics Scale 2 (CTS-2) which asks about specific behaviors rather than asking about abuse generally.[50] The CTS-2 is the standard in violence research,[51] and CTS-2-based questionnaires have been used successfully in diverse samples of FSW.[52, 53] Formative research also informed development of setting-specific behaviors, such as common types of physical abuse from pimps or momkas and *subbotnik*, or coerced sex with police officers in order to avoid arrest.[21]

Table 3.1: Survey items measuring lifetime violence victimization exposures of interest.

Source	Measure
Intimate partner	Think about your boyfriends, husband, or other people you have dated. Have you been hit, pushed, slapped, or otherwise physically hurt by a boyfriend, husband, or someone you were dating?
Client	Have you been hit, pushed, slapped, or otherwise physically hurt by a client?
	Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a client?
	Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>vaginal</i> sex when you didn't want to?
	Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>anal</i> sex when you didn't want to?
Pimp/momka	Have you been hit, pushed, slapped, or otherwise physically hurt by a pimp/momka?
	Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a pimp/momka?
	Has your pimp ever forced you to have sex when you did not want to?
Police	How many times have you been involved in a subbotnik (asked to provide sex to police or militia to avoid incarceration or arrest)?

	In the past 6 months, have you had to pay or compensate the police for the ability to sell sex or stand on the street? Options include: Yes, had to provide sex
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There were two additional client violence measures available in the survey specific to pressured or coerced vaginal or anal sex, “Have you had a client pressure you for or insist on *vaginal* sex when you did not want to (but did not use physical force)?” and “Have you had a client pressure you for or insist on *anal* sex when you did not want to (but did not use physical force)?” Because there were not similar measures on pressured or coerced sex for any other type of perpetrator, these two items were not used in the main analysis. The 4-item assessment was used in the main analysis to enhance comparability across perpetrators. A sensitivity analysis was undertaken comparing the results of the 4-item assessment with the available 6-item assessment for client violence. Results using the 6-item definition of client violence (inclusive of sexual coercion) were qualitatively similar to results using the 4-item definition restricted to forced sex.

Missing data

Multiple imputation with chained equations was used to impute missing data. The amount of missing data for each variable used in the analysis ranged from 0.3% to 10.4%; intimate partner violence was the only variable missing more than 10% of values. Approximately 16% of the sample was missing at least one of the four key violence exposure variables (0.4% for pimp violence, 2.1% for police violence, 7.6% for client violence, and 10.4% for intimate partner violence). Key exposure variables, variable indicating cluster membership, potential demographic confounders, and all variables found to be associated with key exposure variables or associated with missingness in those variables, were identified for inclusion in the imputation model. Because of difficulties with model convergence due to the number of variables, variables that were missing less than 2% of values were imputed using the mean or mode of respondents in the same recruitment chain. The remaining variables were imputed via multiple imputation with 20 multiply imputed datasets.

Analyses

Data were collected via respondent-driven sampling (RDS), including provision of recruitment coupons and tracking of recruitment chains. However, participants were unable to answer questions about network size, and therefore RDS-adjusted statistics (i.e. population-based estimates) could not be calculated; estimates are therefore only representative of the sample rather than the entire population of FSW. All regressions are performed with complex survey adjustment for intracluster correlation by strata (city) and cluster (recruitment chain). This accounts for the non-independence within recruitment chains; specifically, individuals are more likely to recruit their peers who are more similar to them in their covariate and outcome values than someone randomly drawn from the entire population of FSW.

Descriptive statistics were calculated to report 1) the prevalence of the four types of violence (client, police, intimate partner, and pimp violence); 2) the prevalence of experiencing one type of violence (monovictimization) versus two, three, or four types (polyvictimization); and 3) the prevalence of experiencing each violence profile (16 possible profiles from four binary exposures). We use the term “polyvictimization” to refer to experiencing more than one of the four types of violence, and the term “monovictimization” to distinguish those who experience exactly one type of violence. We calculate the expected prevalence of each violence profile if each type of violence were randomly distributed throughout the sample while maintaining the same overall prevalence (i.e. multiplying the independent probabilities of experiencing or not experiencing each type of violence), and used the Clopper-Pearson exact method[54] to determine if the observed proportion of individuals in the dataset who experience a specific violence profile significantly differ from what would be expected by chance.

We then seek to understand associations between different types of violence, corresponding to the idea in polyvictimization that exposures are mutually reinforcing and that experiencing one type of violence may increase risk for other types of violence. We use a series of multivariate log-binomial

regression models (or Poisson regression models where log-binomial models fail to converge) to evaluate if the four types of violence are associated with one another. For each of the twelve possible pairwise combinations of violence types (unlike odds ratios, relative risks are not symmetrical, necessitating the use of 12 combinations rather than 6), we build three separate models: model 1 (crude RR without adjustment), model 2 (adjusted RR adjusted only for other types of violence), and model 3 (adjusted RR adjusted for other types of violence and demographic variables).

The following potential confounders are included as covariates in model 3 based on a review of the literature and bivariate association with at least one type of violence at $p < 0.1$: age,[55, 56] engaging in street-based sex work,[10, 14, 45, 57, 58] average number of vaginal or anal sex clients per night,[16] having another income besides sex work,[10, 59] current number of non-paying intimate partners,[9] duration of time in sex work,[59] education level,[11] age of entry into sex work,[18, 60] relationship status,[59, 61] and monthly salary.[62].

A cluster analysis was conducted to understand major groups of FSW as classified by violence type. Average-linkage simple agglomerative hierarchical clustering, with the four binary violence exposure measures as the cluster-defining variables, was used to identify groups of women experiencing similar patterns of violence clustering.[63] Average-linkage clustering uses the unweighted pair group method with arithmetic mean (UPGMA) to determine cluster groupings. This algorithm agglomerates based on the average distance between an individual in cluster A and an individual in cluster B, and is robust and performs well even with clusters of different sizes.[64] Distance between clusters was calculated using binary distance, also known as the Jaccard dissimilarity coefficient, rather than Euclidean distance, as it is considered more appropriate for binary indicators.[65] The clustering algorithm was run on each of the 20 multiply imputed datasets and results were synthesized across datasets. A multinomial logistic regression model was used to determine if cluster membership was associated with demographic and sex work context covariates. Multinomial logistic regression was chosen over multinomial Poisson

regression due to greater ease of implementation in STATA and because multinomial logistic regression is more commonly used in the field.

Results

Distribution of types of violence and of polyvictimization in the sample

Figure 1 shows the lifetime prevalence of each type of violence and each victimization profile. Client violence (31.7%) was more common than police (16.0%), intimate partner (15.7%), or pimp (11.4%) violence. Slightly less than half the sample (44.8%) experienced at least one type of violence (Table 2). Of those who experienced at least one type of violence, 45.4% experienced polyvictimization (20.4% of the total sample).

Figure 3.1: Lifetime prevalence of client, police, intimate partner, and pimp violence among a sample of Russian FSW (n=754).

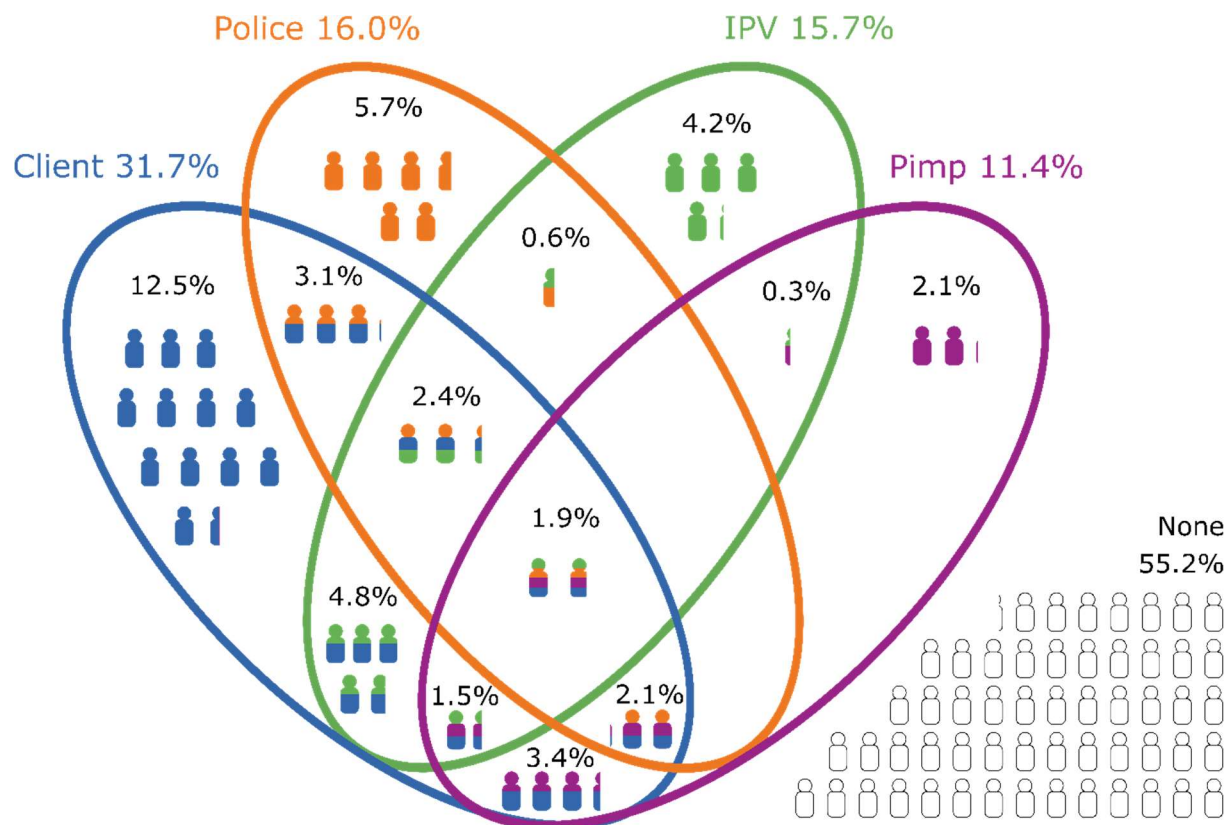


Table 3.2: Number of types of violence experienced (N=754) and prevalence of each type of violence among polyvictims (N=154).

	%
No violence	55.2
At least one form of violence	44.8
Monovictimization	
One type of violence	24.5
Polyvictimization	
Two types of violence	12.2
Three types of violence	6.3
Four types of violence	1.9
Any polyvictimization (2 to 4 types of violence)	20.4
Types of violence experienced among polyvictims (n=154*)	
	Prevalence among polyvictims (%)
Client violence	94.1
Police violence	49.5
Intimate partner violence	56.4
Pimp violence	45.1

* sample size of polyvictims varies slightly by imputation dataset

Client violence was the defining experience of polyvictimization, with virtually all polyvictims (94.1%) experiencing client violence, as compared to 49.5% of polyvictims experiencing police violence, 56.4% experiencing IPV, and 45.1% experiencing pimp violence (Table 2). While over 20% of FSW experienced polyvictimization, just 0.9% of FSW are polyvictims who did not experience client violence (Figure 1). This indicates that polyvictimization frequently occurs without police, intimate partner, or pimp violence, but almost never occurs without client violence.

When client violence is not present, intimate partner violence, pimp violence, and police violence co-occur less frequently than would be expected by random chance (Table 3). IPV and pimp violence

occur in 0.3% of the sample where 1.0% is expected ($p=0.041$), IPV and police violence occur in 0.6% where 1.5% is expected ($p=0.052$), police and pimp violence occur in 0% where 1.1% is expected ($p<0.001$), and IPV, police, and pimp violence occur in 0% where 0.2% is expected ($p=0.277$). Taken together, the expected occurrence of these four victimization profiles is 3.8% and the observed prevalence is 0.9% ($p<0.001$) (not shown in table). These three types of violence rarely co-occur with one another, unless client violence is also present.

Table 3.3: Observed and expected lifetime prevalence of each violence profile (N=754)

	Observed sample Prevalence (%)	Expected prevalence (%)	p-value	Direction of difference where significant differences observed
No violence	55.2	42.9	<0.001	More than expected
One type of violence (monovictimization)	24.5	41.5	<0.001	Less than expected
IPV alone	4.2	8.0	<0.001	Less than expected
Client violence	12.5	19.9	<0.001	Less than expected
Police violence	5.7	8.2	0.011	Less than expected
Pimp violence	2.1	5.5	<0.001	Less than expected
Two types of violence	12.2	13.6	0.265	
IPV + client violence	4.8	3.7	0.122	
IPV + pimp violence	0.3	1.0	0.041	Less than expected
IPV + police violence	0.6	1.5	0.052	
Client + pimp violence	3.4	2.6	0.137	
Client + police violence	3.1	3.8	0.340	
Police + pimp violence	0.0	1.1	<0.001	Less than expected
Three types of violence	6.3	1.9%	<0.001	More than expected
IPV + client + police	2.4	0.7	<0.001	More than expected
IPV + client + pimp	1.5	0.5	0.002	More than expected
Client + police + pimp	2.1	0.5	<0.001	More than expected
IPV + police + pimp	0.0	0.2	0.277	
Four types of violence	1.9	0.1	<0.001	More than expected

Monovictimization with any type of violence occurs roughly 40% less than would be expected by chance ($p<0.001$, Table 3). For example, experiencing IPV alone is observed in 4.2% of the sample, when it would be expected in 8.0% of the sample if each type of violence occurred independently at random ($p<0.001$).

There are strong bivariate associations between each type of violence and every other type of violence at $p<0.001$ (Table 4). For instance, 30.7% of those experiencing police violence also experience IPV, whereas only 12.8% of those who do not experience police violence experience IPV (relative risk (RR) 2.39, 95% CI 1.68, 3.40). While all four types of violence are associated with one another, the bivariate associations between client violence and the other types of violence are particularly strong. Exposure to client violence was associated with the outcomes of police violence (RR=3.19, 95% CI 2.08, 4.89), IPV (RR=4.38, 95% CI=2.33, 8.23), and pimp violence RR=7.55, 95% CI 3.91, 14.59). These associations persisted after adjustment for other types of violence experienced and demographic factors; specifically client violence was associated with police violence (ARR=2.77, 95% CI 1.67, 4.59), IPV (ARR=3.67, 95% CI 1.95, 6.89), and pimp violence (ARR=5.26, 95% CI 2.80, 9.86), all at $p<0.001$. In contrast, the bivariate associations observed between police, intimate partner, and pimp violence did not persist after adjustment for other types of violence experienced and demographic factors, with the sole exception of pimp violence being associated with police violence (ARR 1.33, 95% CI 1.05, 1.68). Client violence is more strongly associated with IPV, pimp violence, and police violence than nearly any other demographic or sex work context variable (see Appendix Table 1 for full results of multivariate models, including coefficients for demographic and sex work context variables).

Table 3.4: Crude and adjusted relationships between violence exposure variables (N=754)

Outcome	Exposure	Prevalence of the outcome among exposed vs unexposed (%)	Bivariate relative risk (RR) RR (95% CI)	ARR adjusted for other types of violence experienced ARR (95% CI)	ARR adjusted for other types of violence and demographics ARR (95% CI)
Police	Client	30.1 vs 9.5	3.19 (2.08, 4.89)***	2.45 (1.62, 3.70)***	2.77 (1.67, 4.59)***
	IPV	31.3 vs 13.2	2.38 (1.70, 3.34)***	1.53 (1.06, 2.19)*	1.27 (0.87, 1.84)
	Pimp	36.6 vs 13.4	2.74 (1.90, 3.95)***	1.68 (1.23, 2.29)**	1.33 (1.05, 1.68)*
IPV	Client	33.2 vs 7.6	4.38 (2.33, 8.23)***	3.82 (1.93, 7.56)***	3.67 (1.95, 6.89)***
	Police	30.7 vs 12.8	2.39 (1.68, 3.40)***	1.51 (1.05, 2.18)*	1.49 (0.99, 2.24)
	Pimp	32.7 vs 13.5	2.41 (1.65, 3.53)***	1.15 (0.81, 1.63)	1.19 (0.83, 1.72)
Pimp	Client	28.0 vs 3.7	7.55 (3.91, 14.59)***	6.35 (3.23, 12.50)***	5.26 (2.80, 9.86)***
	Police	26.1 vs 8.6	3.03 (1.96, 4.70)***	1.74 (1.23, 2.48)**	1.19 (0.86, 1.63)
	IPV	23.7 vs 9.1	2.60 (1.65, 4.11)***	1.17 (0.79, 1.75)	1.11 (0.75, 1.65)
Client	Police	59.7 vs 26.4	2.26 (1.72, 2.98)***	1.59 (1.25, 2.02)***	1.61 (1.16, 2.24)**
	IPV	67.0 vs 25.1	2.67 (1.79, 3.97)***	2.05 (1.39, 3.04)***	1.86 (1.33, 2.59)***
	Pimp	77.8 vs 25.7	3.02 (2.20, 4.15)***	2.25 (1.64, 3.09)***	1.86 (1.47, 2.35)***

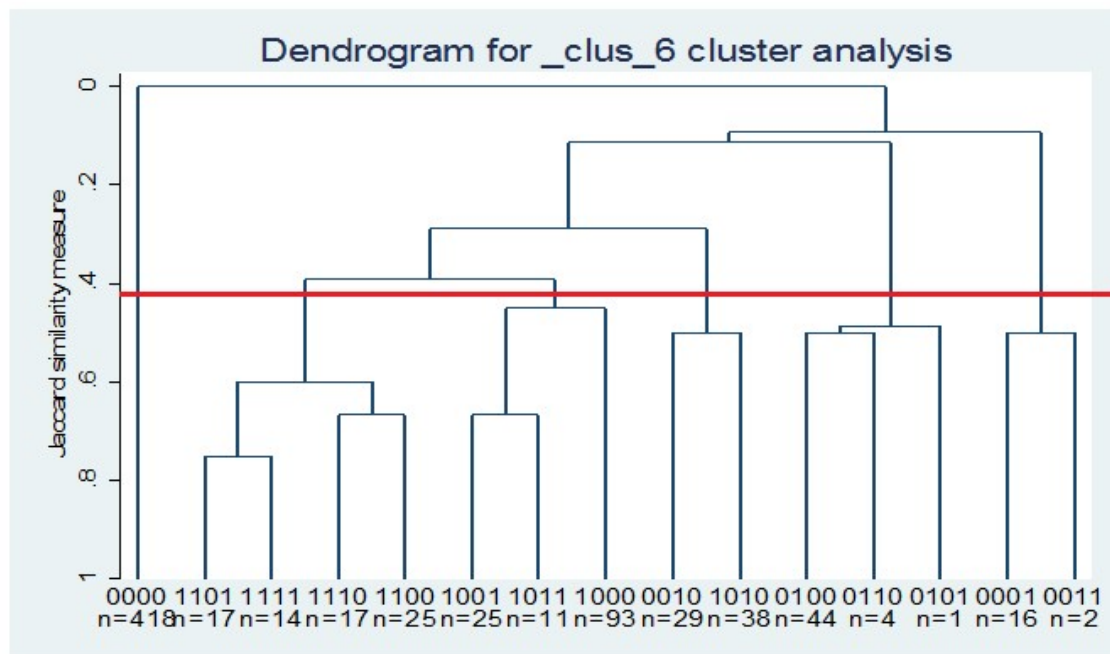
* <0.05, **<0.01, ***<=0.001

Describing clusters of victimization profiles

Out of the 16 victimization profiles possible with four binary violence exposures, we ultimately identified 6 clusters that best described the major victimization profiles in this sample. Cluster analysis was sensitive to slight variations between imputation datasets, with 5 unique clustering solutions identified depending on which imputed dataset was used to run the clustering algorithm (See Methods Chapter for further details). The greatest number of datasets (n=6) identified the following six-cluster solution (Figure 2): 1) *no violence* (55.3% of the sample) 2) *client violence* (all members experienced client violence and some also experienced intimate partner or pimp violence, 17.3% of the sample), 3) *highly polyvictimized* (the only cluster comprised of all polyvictims; all individuals experienced client and police violence and many also experienced intimate partner or pimp violence; 9.5% of the sample), 4) *IPV* (all members experienced IPV and some also experienced client violence; 9.0% of the sample), 5) *police violence* (all members experienced police violence and a few also experienced IPV or pimp violence;

6.4% of the sample), and 6) *pimp violence* (all members experienced pimp violence and some also experienced IPV, 2.4% of the sample). The dendrogram for imputed dataset #1 (Figure 2) was cut at a point that yielded 6 clusters rather than 4 to avoid having one cluster with 9 profiles in it; the 6-cluster solution split this one cluster into 3 clusters so that meaningful subgroups were identified. Figure 3 shows the prevalence of each violence type within each cluster.

Figure 3.2: Dendrogram showing results of clustering algorithm on imputed dataset #1.



*Red line indicates the cut point at which the 6 cluster groups were identified.

**Violence exposure groups are labeled on the x-axis with a 4-digit code indicating whether that group experienced (1) or did not experience (0) client, police, intimate partner, or pimp violence, respectively. For instance, 1100 indicates the group that experienced client and police violence but did not experience intimate partner or pimp violence.

***n's indicate the number of people in each violence exposure group.

Table 3.5: Prevalence of membership in each cluster (6-cluster solution) (N=754)

#	Cluster name	Prevalence of cluster within sample n (%) *	Profiles included in cluster	Violence prevalence within cluster			
				Client (%)	Police (%)	IP (%)	Pimp (%)
0	No violence	417 (55.3)	No violence experienced	0	0	0	0
1	Client	130 (17.3)	Client alone, client/pimp, client/IPV/pimp	100	0	8.4	27.9
2	Highly polyvictimized	72 (9.5)	Client/police, client/police/pimp, client/police/IPV, all types	100	100	44.6	42.4
3	IPV	68 (9.0)	IPV alone, IPV/client	53.3	0	100	0
4	Police	48 (6.4)	Police alone, police/IPV, police/pimp	0	100	9.4	0.1
5	Pimp	18 (2.4)	Pimp alone, pimp/IPV	0	0	12.7	100

*Due to multiple imputation, n is approximate and varies slightly by imputation dataset

Results of the multinomial logistic regression model predicting cluster membership are shown in Table 6. Age, street-based sex work, client volume, and having another income outside of sex work were not associated with membership in any cluster. Dating someone (AOR 2.92, 95% CI 1.71, 4.99) or being divorced or separated (AOR 3.05, 95% CI 1.46, 6.37) as opposed to never having been married, entering sex work at a younger age (AOR 0.85, 95% CI 0.75, 0.96), and having a higher salary (AOR 1.02, 95% CI 1.01, 1.03) were associated with membership in the Client cluster as opposed to the No Violence cluster. Dating someone as opposed to having never been married (AOR 3.16, 95% CI 1.38, 7.26), lower education (AOR 0.40, 95% CI 0.22, 0.72), and having been in sex work longer (AOR 2.59, 95% CI 1.51, 4.46) were associated with membership in the Highly Polyvictimized cluster. Having more intimate partners (AOR 1.61, 95% CI 1.05, 2.47), living together with someone as though married (AOR 2.07, 95% CI 1.07, 4.00) or being divorced or separated (AOR 3.03, 95% CI 1.05, 8.77), and having a higher salary (AOR 1.01, 95% CI 1.00, 1.03) were associated with membership in the IPV cluster. Being in sex

work for longer (AOR 1.56, 95% CI 1.14, 2.13) and having a lower salary (AOR 0.98, 95% CI 0.96, 1.00) were associated with membership in the Police cluster. The small size of the Pimp cluster (2.4% of FSW were in this cluster) likely left the analysis underpowered to identify significant correlates of cluster membership.

Table 3.6: Multinomial logistic regression model showing associations between demographic factors and cluster membership, compared to membership in the reference No Violence cluster (N=754)

	Client cluster AOR (95% CI)	Highly polyvictimized cluster AOR (95% CI)	IPV cluster AOR (95% CI)	Police cluster AOR (95% CI)	Pimp cluster AOR (95% CI)
Age	1.02 (0.91, 1.15)	0.99 (0.87, 1.13)	1.00 (0.84, 1.19)	0.90 (0.80, 1.01)	0.84 (0.64, 1.12)
Any street SW	1.38 (0.75, 2.53)	1.80 (0.56, 5.73)	1.40 (0.77, 2.54)	1.19 (0.49, 2.89)	1.41 (0.29, 6.87)
Avg # of sex partners per night	1.22 (0.89, 1.67)	0.83 (0.52, 1.32)	1.22 (0.85, 1.74)	0.98 (0.77, 1.24)	0.99 (0.65, 1.53)
Other income besides sex work	1.41 (0.79, 2.52)	0.47 (0.18, 1.26)	1.16 (0.59, 2.26)	1.06 (0.53, 2.11)	0.18 (0.02, 1.47)
Current number of intimate partners	0.81 (0.51, 1.30)	0.92 (0.49, 1.70)	1.61 (1.05, 2.47)*	1.76 (0.93, 3.35)	0.87 (0.42, 1.78)
Sex work duration	1.09 (0.87, 1.37)	2.59 (1.51, 4.46)*	1.06 (0.68, 1.65)	1.56 (1.14, 2.13)*	1.52 (0.86, 2.67)
Education	0.66 (0.42, 1.03)	0.40 (0.22, 0.72)*	1.02 (0.63, 1.66)	1.13 (0.80, 1.59)	0.83 (0.25, 2.71)
Age of entry	0.85 (0.75, 0.96)*	0.97 (0.82, 1.14)	0.91 (0.76, 1.09)	1.07 (0.92, 1.24)	1.21 (0.92, 1.60)
Relationship					
Never married	Ref	Ref	Ref	Ref	Ref
Dating someone	2.92 (1.71, 4.99)*	3.16 (1.38, 7.26)*	1.29 (0.61, 2.74)	0.39 (0.12, 1.01)	1.07 (0.26, 4.44)
Living together	1.55 (0.63, 3.81)	1.68 (0.70, 4.04)	2.07 (1.07, 4.00)*	0.59 (0.17, 2.03)	0.94 (0.13, 6.90)
Legally married or widowed	0.21 (0.02, 1.79)	1.07 (0.30, 3.81)	1.65 (0.39, 6.90)	1.27 (0.37, 4.37)	0.87 (0.07, 10.30)
Divorced or separated	3.05 (1.46, 6.37)*	1.93 (0.88, 4.23)	3.03 (1.05, 8.77)*	0.29 (0.06, 1.47)	1.00 (0.23, 4.41)
Monthly salary in 1000s rubles	1.02 (1.01, 1.03)*	1.01 (1.00, 1.03)	1.01 (1.00, 1.03)*	0.98 (0.96, 1.00)*	1.01 (1.00, 1.03)

* <0.05, **<0.01, ***<=0.001

Discussion

In this sample of Russian FSW, client, police, intimate partner, and pimp violence were prevalent and 20.4% of women had experienced polyvictimization. These types of violence formed a tightly clustered constellation that seemed to revolve around client violence. Client violence was not only the most prevalent type of violence, but was also a strong and highly independently significant correlate for the other three types of violence. Indeed, client violence was more strongly associated with IPV, pimp, and police violence than nearly any other demographic or sex work context variable.

Causal explanations

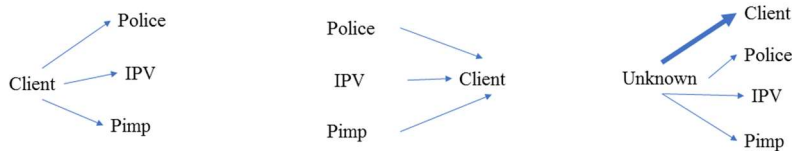


Figure 3.3: Potential causal explanations for the results observed.

These four types of violence seem to form a constellation with client violence at the center, but what precise shape does this constellation take? The simplest causal explanation for the observed data is that client violence is somehow promoting risk for other types of violence in this setting (Fig 3, left). This causal pathway would be consistent with our findings that client violence occurs in virtually all polyvictimization situations. It would also be consistent with our finding that client violence is significantly and independently associated with the three other types of violence. For instance, client violence may lead to police violence if women seek recourse from police following client violence, or commotion caused by client violence draws the attention of law enforcement; this contact with law enforcement increases the potential for police violence. In many settings, client violence frequently occurs in the context of negotiating payment for sex or occurs when the client refuses to pay or robs the

sex worker.[66] These lost wages could trigger violence from intimate partners or pimps who often take a cut of the money.[67] Although FSW often do not report theft or violence to the police, this type of client violence could lead to police violence if a woman reports the robbery to police and is abused.[68] For FSW who have not disclosed their sex work to their intimate partners, observable injuries from client violence may also trigger revelation of their occupation; partner discovery of sex work status is a frequent trigger of abuse from intimate partners.[32]

Alternatively, it may be that there are causal mechanisms in the other direction: being exposed to police, intimate partner, or pimp violence increases the risk of subsequently experiencing client violence (Figure 3, center). Intimate partners may initiate violence to push women to sell sex to more clients or riskier clients to make more money or obtain drugs;[32, 34] women may also engage in riskier sex work where they may be more vulnerable to client violence in order to become financially independent from abusive partners.[13] Pimps may use physical and sexual violence[18] to ensure compliance with higher client volume or riskier clients than the sex worker would otherwise choose,[22, 32] which could increase exposure to client violence. Police violence and harassment pushes sex workers more underground where they may be forced to take riskier or more violent clients.[17, 33, 34]

A third explanation would be that an unmeasured confounder drives all four types of violence, but drives client violence particularly strongly (Figure 3, right). Empirically, it would be impossible to distinguish this scenario from the first scenario where client violence is causally linked to the other types of violence. One such potential confounder would be serious financial need, which may broadly raise vulnerability to different types of violence, but might most directly lead women to take on riskier clients to meet immediate financial needs.

Implications for interventions

Our findings show that client violence is strongly associated with police, intimate partner, and pimp violence, and that approximately 40% of people experiencing client violence experience one of these other types of violence. If this association is causal and client violence is actually precipitating the other three forms of violence, primary prevention of client violence could substantially lower victimization from other types of violence as well. Given evidence from the syndemic and polyvictimization literatures that there is a dose-response effect whereby accumulating a greater number of types of victimization steadily increases health risks such as HIV,[69-71] bringing down the number of types of violence experienced could crucially alter outcomes across many domains of health and could be accomplished efficiently by targeting client violence. If bidirectional causation occurs between client violence and the other types of violence, then targeting multiple types of violence in concert will be critical, as we would expect any one type of violence to be intractable to prevent unless the other types are also addressed.

With secondary prevention or response interventions, these findings affirm that addressing the impact of just one type of violence is an overly narrow approach. Polyvictimization is common, with 20.4% of the sample and nearly half of violence victims (46%) being polyvictims. When working with survivors of violence, violence response programs should be sure to comprehensively assess violence these women may be experiencing from multiple sources and not just the first type of violence she may have disclosed, as other types of trauma are likely. Interventions that address one type of violence are also an efficient way of identifying women who have been exposed to another type of violence. For instance, while pimp violence affects roughly 1 in 9 women, a program working with women who experienced client violence could expect more than 1 in 4 women to have experienced pimp violence as well. The reverse is also true; while client violence affects roughly 1 in 3 FSW, a program working with victims of pimp violence could expect roughly 4 out of 5 women to have experienced client violence. Experiencing one type of violence is a strong risk factor for experiencing any other type of violence, as shown by the highly significant bivariate risk ratios between all pairwise combinations of violence types.

The results from multivariate regression models including demographic covariates also suggest that relationship status may be an underappreciated way to identify women at highest risk for violence, particularly client violence. Unsurprisingly, having more intimate partners was associated with intimate partner violence, but relationship status was also a strong correlate of client violence. Women who were dating someone, women who were living with someone as though married, and women who were divorced or separated were all roughly two times as likely to experience client violence as those who were never married, adjusting for other violence experienced and demographic factors. Causal explanations for this observed relationship are unclear. This may be a reflection of the fact that in many settings, intimate partners may start off as clients before becoming boyfriends.[67] It could also reflect greater precariousness in FSW's living situation when FSW are involved in relationships that are not legally binding marriages (in the case of women who are dating or living with someone) or when they extricate themselves from relationships (in the case of women who are divorced or separated). Finally, it could reflect partners pushing FSW to engage in more or riskier sex work to obtain more money for the couple, increasing exposure to client violence.[32] Regardless of the mechanism, relationship status was strongly linked to client violence and should be considered in intervention programming as a risk factor for client violence. Interventions to reduce client violence should also not just focus on interactions between FSW and their clients, but also take into account how intimate relationship context may be shaping risk.

Implications for research

Findings indicate that it is critical for surveys and HIV surveillance systems to address violence and to address multiple, distinct types of violence. Many studies of violence against FSW do not distinguish between perpetrators or only measure violence by one type of perpetrator.[5, 60, 72-74] This study expands knowledge of how multiple types of violence are distributed in the population and shows that different types of violence are different in prevalence and are more likely to affect different demographic segments of the population. Due to the clustering effect between types of violence, inquiring

about one type of violence is likely insufficient to fully assess cumulative exposure to violence among FSW.

Findings also extend polyvictimization and syndemic[75] frameworks, which often present all types of violence as potentiating all the other types of violence. Our findings suggest that not all types of violence are equal in increasing risk for the other types of violence. It may be that only some types of violence (in this study, client violence) increase risk for other types of violence, or that the effect of some types of violence in potentiating risk is stronger than other types.

We performed a cluster analysis to better understand how multiple forms of violence cluster in this population, but ultimately this methodology was not highly informative. Because client violence was so strongly associated with the other three types of violence, it appeared in 3 of the 5 clusters that had at least some violence, making clusters less distinct from one another. Further, because several of the clusters were dominated primarily by one form of violence (particularly the Client and Pimp clusters), predictors of membership in those clusters were highly similar to predictors of those types of violence. The multinomial regression predicting cluster membership therefore did not add substantive insights to the results gleaned from regressions earlier in the chapter. Future cluster analyses may be more informative if information about frequency or severity of violence is included in order to better distinguish between clusters. Alternatively, measuring 5 or 6 types of violence may increase the ability to distinguish between clusters and also allow for the use of alternative methodologies such as latent class analysis in a large dataset (see Methods Chapter).

Findings should be considered in the light of several limitations, particularly the cross-sectional nature of the survey. Longitudinal data would help establish temporality and narrow down potential causal mechanisms for the patterns observed in the study. Qualitative data would also help put results in context and suggest pathways by which each type of violence may potentiate risk for other types of violence. Because some violence profiles happen relatively infrequently, our sample size of 754 yielded small cell sizes for some violence combinations, causing some multivariate regressions to potentially be underpowered. Measurement limitations include inconsistencies in how different types of violence were

assessed in the survey, with client violence likely being the most sensitive measure; police were not assessed as potential physical violence perpetrators and intimate partners were not assessed as potential sexual violence perpetrators. It is possible that results showing strong associations between client violence and other forms of violence may be due to the fact that clients in many settings may over time transition into intimate partner and pimp roles.[67] For instance, some FSW may have experienced one incident of violence from a client-cum-intimate partner and based on this one incident reported having experienced both client violence and intimate partner violence. If FSW answered questions in this way, it would artificially increase the associations between client violence and intimate partner violence, between client violence and pimp violence, and between intimate partner and pimp violence. Further, police officers sometimes act as clients and purchase sex, which could cause conflation of client and police violence.[68] However, this type of information bias would not affect findings that intimate partner, pimp, and police violence co-occur less than would be expected by chance in the absence of client violence. Further, we likely would have observed more extensive co-occurrence between intimate partner and pimp violence if this permeability between client, intimate partner, and pimp categories were a substantial source of bias. Measuring violence severity or chronicity would also add valuable dimensions to our understanding of how these types of violence overlap. Given the focus on lifetime exposure, one could argue that childhood abuse is an important type of violence that was not included; however, the choice was made to focus on exposures that would have happened largely during adulthood for comparability.

Conclusion

We found that polyvictimization is common, and almost never occurs without client violence and that IPV, pimp violence, and police violence rarely co-occur unless client violence is also present. Client violence was strongly associated with intimate partner, pimp, and police violence, even after adjusting for a range of other factors. While the cross-sectional nature of the survey precludes conclusions of causality, these striking patterns raise intriguing hypotheses around the centrality of client violence in polyvictimization. It also raises potential implications for how violence and HIV interventions should be

targeted and structured, including adding a focus on client violence to prevention and response interventions for other types of violence. As more surveys with FSW include assessments for multiple types of violence, a better understanding of polyvictimization and patterns of violence co-occurrence across settings will emerge, supporting the development of evidence-based interventions in this key population.

Appendix

Table 3.A1: Multivariate models for client, police, intimate partner, and pimp violence outcomes (N=754)

	Outcome			
	Client violence ARR (95% CI)	Police violence ARR (95% CI)	IPV ARR (95% CI)	Pimp violence ARR (95% CI)
Client violence	---	2.77 (1.67, 4.59)***	3.67 (1.95, 6.89)***	5.26 (2.80, 9.86)***
Police violence	1.61 (1.16, 2.24)**	---	1.49 (0.99, 2.24)	1.19 (0.86, 1.63)
IPV	1.86 (1.33, 2.59)***	1.27 (0.87, 1.84)	---	1.11 (0.75, 1.65)
Pimp violence	1.86 (1.47, 2.35)***	1.33 (1.05, 1.68)*	1.19 (0.83, 1.72)	---
Age	1.00 (0.95, 1.05)	0.96 (0.92, 1.01)	0.99 (0.91, 1.08)	1.04 (0.96, 1.12)
Any street SW	1.08 (0.83, 1.41)	1.24 (0.74, 2.08)	1.21 (0.82, 1.79)	1.09 (0.56, 2.15)
Avg # of sex partners per night ¹	1.07 (0.86, 1.32)	0.87 (0.76, 1.01)	1.04 (0.89, 1.22)	1.03 (0.84, 1.26)
Other income besides sex work	1.17 (0.92, 1.49)	0.78 (0.38, 1.27)	0.97 (0.61, 1.53)	0.40 (0.18, 0.89)*
Current number of intimate partners ²	0.80 (0.61, 1.05)	1.21 (0.86, 1.71)	1.55 (1.12, 2.13)*	1.01 (0.70, 1.44)
Sex work duration ³	1.04 (0.95, 1.14)	1.56 (1.25, 1.95)***	1.08 (0.81, 1.44)	1.23 (1.01, 1.49)*
Education	0.84 (0.70, 1.01)	0.96 (0.75, 1.25)	1.10 (0.87, 1.40)	0.90 (0.58, 1.40)
Age of entry	0.94 (0.89, 0.99)*	1.06 (0.98, 1.14)	0.97 (0.88, 1.08)	0.96 (0.89, 1.04)
Relationship				
Never married	---	---	---	---
Dating someone	1.97 (1.43, 2.71)***	0.72 (0.49, 1.05)	0.64 (0.39, 1.04)	1.00 (0.63, 1.59)
Living together	1.73 (1.20, 2.49)**	0.67 (0.40, 1.11)	0.99 (0.59, 1.67)	0.82 (0.52, 1.29)
Legally married or widowed	0.79 (0.43, 1.44)	1.17 (0.61, 2.26)	1.50 (0.71, 3.16)	0.24 (0.03, 1.98)
Divorced or separated	2.02 (1.48, 2.75)***	0.54 (0.27, 1.07)	1.09 (0.49, 2.42)	0.52 (0.19, 1.40)
Monthly salary in 1000s rubles	1.01 (1.00, 1.01)***	0.99 (0.98, 1.01)	1.00 (1.00, 1.01)	1.00 (1.00, 1.01)

* <0.05, **<0.01, ***<=0.001

¹ Average number of vaginal or anal sex partners. Ordered categorical variable with response options 0, 1, 2, 3, or more than 3

² Ordered categorical variable with response options 0, 1, or 2 or more

³ Ordered categorical variable with response options 6 months or less, 6 months to 1 year, 1-2 years, 2-3 years, 3-4 years, more than 4 years

References

1. Decker MR, Crago A-L, Chu SK, Sherman SG, Seshu MS, Buthelezi K, et al. Human rights violations against sex workers: burden and effect on HIV. *The Lancet*. 2014.
2. Baral S, Beyrer C, Muessig K, Poteat T, Wirtz AL, Decker MR, et al. Burden of HIV among female sex workers in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet infectious diseases*. 2012;12(7):538-49.
3. Shannon K, Kerr T, Allinott S, Chettiar J, Shoveller J, Tyndall MW. Social and structural violence and power relations in mitigating HIV risk of drug-using women in survival sex work. *Social science & medicine*. 2008;66(4):911-21.
4. Rhodes T. The 'risk environment': a framework for understanding and reducing drug-related harm. *International journal of drug policy*. 2002;13(2):85-94.
5. Ulibarri MD, Strathdee SA, Ulloa EC, Lozada R, Fraga MA, Magis-Rodríguez C, et al. Injection drug use as a mediator between client-perpetrated abuse and HIV status among female sex workers in two Mexico-US border cities. *AIDS and Behavior*. 2011;15(1):179-85.
6. Garcia-Moreno C, Jansen HA, Ellsberg M, Heise L, Watts CH. Prevalence of intimate partner violence: findings from the WHO multi-country study on women's health and domestic violence. *The Lancet*. 2006;368(9543):1260-9.
7. Mayhew S, Collumbien M, Qureshi A, Platt L, Rafiq N, Faisel A, et al. Protecting the unprotected: mixed-method research on drug use, sex work and rights in Pakistan's fight against HIV/AIDS. *Sexually transmitted infections*. 2009;85(Suppl 2):ii31-ii6.
8. Deering KN, Bhattacharjee P, Mohan H, Bradley J, Shannon K, Boily M-C, et al. Violence and HIV risk among female sex workers in Southern India. *Sexually transmitted diseases*. 2013;40(2):168-74.
9. Panchanadeswaran S, Johnson SC, Sivaram S, Srikrishnan AK, Latkin C, Bentley ME, et al. Intimate partner violence is as important as client violence in increasing street-based female sex workers' vulnerability to HIV in India. *International Journal of Drug Policy*. 2008;19(2):106-12.
10. El-Bassel N, Witte SS, Wada T, Gilbert L, Wallace J. Correlates of partner violence among female street-based sex workers: substance abuse, history of childhood abuse, and HIV risks. *AIDS patient care and STDs*. 2001;15(1):41-51.
11. Hong Y, Zhang C, Li X, Liu W, Zhou Y. Partner violence and psychosocial distress among female sex workers in China. *PloS one*. 2013;8(4):e62290.
12. Pack AP, L'Engle K, Mwarogo P, Kingola N. Intimate partner violence against female sex workers in Mombasa, Kenya. *Culture, health & sexuality*. 2014;16(3):217-30.
13. Choudhury SM, Anglade D, Park K. From violence to sex work: agency, escaping violence, and HIV risk among establishment-based female sex workers in Tijuana, Mexico. *Journal of the Association of Nurses in AIDS Care*. 2013;24(4):368-82.
14. Argento E, Muldoon KA, Duff P, Simo A, Deering KN, Shannon K. High prevalence and partner correlates of physical and sexual violence by intimate partners among street and off-street sex workers. *PloS one*. 2014;9(7):e102129.
15. Hawkes S, Collumbien M, Platt L, Lalji N, Rizvi N, Andreasen A, et al. HIV and other sexually transmitted infections among men, transgenders and women selling sex in two cities in Pakistan: a cross-sectional prevalence survey. *Sexually Transmitted Infections*. 2009;85(Suppl 2):ii8-ii16.
16. Decker MR, Wirtz AL, Baral SD, Peryshkina A, Mogilnyi V, Weber RA, et al. Injection drug use, sexual risk, violence and STI/HIV among Moscow female sex workers. *Sexually transmitted infections*. 2012;88(4):278-83.
17. Erausquin JT, Reed E, Blankenship KM. Police-related experiences and HIV risk among female sex workers in Andhra Pradesh, India. *Journal of Infectious Diseases*. 2011;204(suppl 5):S1223-S8.

18. Goldenberg SM, Rangel G, Vera A, Patterson TL, Abramovitz D, Silverman JG, et al. Exploring the impact of underage sex work among female sex workers in two Mexico–US border cities. *AIDS and Behavior*. 2012;16(4):969-81.
19. Pando MA, Coloccini RS, Reynaga E, Fermepin MR, Vaulet LG, Kochel TJ, et al. Violence as a barrier for HIV prevention among female sex workers in Argentina. *PloS one*. 2013;8(1):e54147.
20. Surratt HL, Kurtz SP, Chen M, Mooss A. HIV risk among female sex workers in Miami: the impact of violent victimization and untreated mental illness. *AIDS care*. 2012;24(5):553-61.
21. Decker MR, Wirtz AL, Moguilnyi V, Peryshkina A, Ostrovskaya M, Nikita M, et al. Female sex workers in three cities in Russia: HIV prevalence, risk factors and experience with targeted HIV prevention. *AIDS and behavior*. 2014;18(3):562-72.
22. Ratinthorn A, Meleis A, Sindhu S. Trapped in circle of threats: violence against sex workers in Thailand. *Health care for women international*. 2009;30(3):249-69.
23. Beletsky L, Lozada R, Gaines T, Abramovitz D, Staines H, Vera A, et al. Syringe confiscation as an HIV risk factor: the public health implications of arbitrary policing in Tijuana and Ciudad Juarez, Mexico. *Journal of Urban Health*. 2013;90(2):284-98.
24. Crago A-L. “Bitches Killing the Nation”: Analyzing the Violent State-Sponsored Repression of Sex Workers in Zambia, 2004–2008. *Signs*. 2014;39(2):365-81.
25. Finkelhor D, Ormrod RK, Turner HA. Lifetime assessment of poly-victimization in a national sample of children and youth. *Child abuse & neglect*. 2009;33(7):403-11.
26. Felitti M, Vincent J, Anda M, Robert F, Nordenberg M, Williamson M, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American journal of preventive medicine*. 1998;14(4):245-58.
27. Finkelhor D, Turner H, Ormrod R, Hamby SL. Violence, abuse, and crime exposure in a national sample of children and youth. *Pediatrics*. 2009;124(5):1411-23.
28. Deering KN, Amin A, Shoveller J, Nesbitt A, Garcia-Moreno C, Duff P, et al. A systematic review of the correlates of violence against sex workers. *American journal of public health*. 2014;104(5):e42-e54.
29. Shannon K, Strathdee SA, Goldenberg SM, Duff P, Mwangi P, Rusakova M, et al. Global epidemiology of HIV among female sex workers: influence of structural determinants. *The Lancet*. 2015;385(9962):55-71.
30. Beattie TS, Bhattacharjee P, Ramesh B, Gurnani V, Anthony J, Isac S, et al. Violence against female sex workers in Karnataka state, south India: impact on health, and reductions in violence following an intervention program. *BMC public health*. 2010;10(1):476.
31. Reza-Paul S, Lorway R, O’Brien N, Lazarus L, Jain J, Bhagya M, et al. Sex worker-led structural interventions in India: a case study on addressing violence in HIV prevention through the Ashodaya Samithi collective in Mysore. *The Indian journal of medical research*. 2012;135(1):98.
32. Decker MR, Pearson E, Illangasekare SL, Clark E, Sherman SG. Violence against women in sex work and HIV risk implications differ qualitatively by perpetrator. *BMC public health*. 2013;13(1):876.
33. Shannon K, Strathdee SA, Shoveller J, Rusch M, Kerr T, Tyndall MW. Structural and environmental barriers to condom use negotiation with clients among female sex workers: implications for HIV-prevention strategies and policy. *American journal of public health*. 2009;99(4):659.
34. Shannon K, Csete J. Violence, condom negotiation, and HIV/STI risk among sex workers. *JAMA*. 2010;304(5):573-4.
35. Kenya FIDA. Documenting human rights violations of sex workers in Kenya. Nairobi: Open Society Foundation, 2008.
36. Crago A. Arrest the violence: Human rights abuses against sex workers in Eastern Europe and Central Asia. Sex Workers’ Rights Advocacy network (SWAn). 2009.
37. Ellsberg M, Arango DJ, Morton M, Gennari F, Kiplesund S, Contreras M, et al. Prevention of violence against women and girls: what does the evidence say? *The Lancet*. 2014.
38. USAID. HIV/AIDS Health Profile: Europe and Eurasia Region. 2012.
39. UNAIDS. Report on the Global AIDS Epidemic. Geneva: 2012.

40. Clark F. Gaps remain in Russia's response to HIV/AIDS. *The Lancet*. 2016;388(10047):857.
41. Pokrovskiy V, Ladnaya N, Tushina O, Buravtsova E. HIV-Infection. Informational Bulletin #40 (ВИЧ-Инфекция. Информационный бюллетень №40). Moscow: Federal Scientific and Methodological Center for AIDS Prevention and Control (Федеральный научно-методический центр по профилактике и борьбе со СПИДом), 2015.
42. European Centre for Disease Prevention and Control, WHO Regional Office for Europe. HIV/AIDS surveillance in Europe 2015. Stockholm:: 2016.
43. UNAIDS. Country Progress Report of the Russian Federation on the Implementation of the Declaration of Commitment on HIV/AIDS. Moscow: 2008.
44. Cohen J. Praised russian prevention program faces loss of funds. *Science*. 2010;329(5988):168-.
45. Odinokova V, Rusakova M, Urada LA, Silverman JG, Raj A. Police sexual coercion and its association with risky sex work and substance use behaviors among female sex workers in St. Petersburg and Orenburg, Russia. *International Journal of Drug Policy*. 2014;25(1):96-104.
46. United States Department of State. International Narcotics Control Strategy Report. 2014.
47. Smolskaya T, Yakovleva A, Kasumov V, Gheorgitsa S. HIV sentinel surveillance in high-risk groups in Azerbaijan, Republic of Moldova and in the Russian Federation. Europe: World Health Organisation (WHO). 2004.
48. Ward H, Aral S. Globalisation, the sex industry, and health. *Sexually transmitted infections*. 2006;82(5):345-7.
49. Heckathorn DD. Respondent-driven sampling: a new approach to the study of hidden populations. *Social problems*. 1997:174-99.
50. Straus MA, Hamby SL, Boney-McCoy S, Sugarman DB. The revised conflict tactics scales (CTS2) development and preliminary psychometric data. *Journal of family issues*. 1996;17(3):283-316.
51. Ellsberg M, Heise L, Pena R, Agurto S, Winkvist A. Researching domestic violence against women: methodological and ethical considerations. *Studies in family planning*. 2001;32(1):1-16.
52. Carlson CE, Chen J, Chang M, Batsukh A, Toivgoon A, Riedel M, et al. Reducing Intimate and Paying Partner Violence Against Women Who Exchange Sex in Mongolia Results From a Randomized Clinical Trial. *Journal of interpersonal violence*. 2012;27(10):1911-31.
53. Gupta J, Reed E, Kershaw T, Blankenship KM. History of sex trafficking, recent experiences of violence, and HIV vulnerability among female sex workers in coastal Andhra Pradesh, India. *International Journal of Gynecology & Obstetrics*. 2011;114(2):101-5.
54. Clopper CJ, Pearson ES. The use of confidence or fiducial limits illustrated in the case of the binomial. *Biometrika*. 1934;26(4):404-13.
55. Su S, Li X, Zhang L, Lin D, Zhang C, Zhou Y. Age group differences in HIV risk and mental health problems among female sex workers in Southwest China. *AIDS care*. 2014;26(8):1019-26.
56. Sarkar K, Bal B, Mukherjee R, Saha MK, Chakraborty S, Niyogi SK, et al. Young age is a risk factor for HIV among female sex workers—an experience from India. *Journal of Infection*. 2006;53(4):255-9.
57. Shannon K, Rusch M, Shoveller J, Alexson D, Gibson K, Tyndall MW. Mapping violence and policing as an environmental–structural barrier to health service and syringe availability among substance-using women in street-level sex work. *International Journal of Drug Policy*. 2008;19(2):140-7.
58. Dandona R, Dandona L, Gutierrez JP, Kumar AG, McPherson S, Samuels F, et al. High risk of HIV in non-brothel based female sex workers in India. *BMC Public Health*. 2005;5(1):87.
59. Wirtz A, Peryshkina A, Moguilnyi V, Beyrer C, Decker M. Current and recent drug use intensifies sexual and structural HIV risk outcomes among female sex workers in the Russian Federation. *International Journal of Drug Policy*. 2015.
60. Lang DL, Salazar LF, DiClemente RJ, Markosyan K. Gender based violence as a risk factor for HIV-associated risk behaviors among female sex workers in Armenia. *AIDS and Behavior*. 2013;17(2):551-8.
61. Karandikar S, Gezinski LB. Intimate partner violence and HIV risks among female sex workers of Mumbai, India. *Journal of Ethnic And Cultural Diversity in Social Work*. 2013;22(2):112-28.

62. Weine S, Golobof A, Bahromov M, Kashuba A, Kalandarov T, Jonbekov J, et al. Female migrant sex workers in Moscow: gender and power factors and HIV risk. *Women & health*. 2013;53(1):56-73.
63. STATA. Cluster - Introduction to cluster-analysis commands.
64. Kaufman L, Rousseeuw PJ. Finding groups in data: an introduction to cluster analysis: John Wiley & Sons; 2009.
65. Greenacre M, Primicerio R. Multivariate analysis of ecological data: Fundacion BBVA; 2014.
66. Lim S, Peitzmeier S, Cange C, Papworth E, LeBreton M, Tamoufe U, et al. Violence against female sex workers in Cameroon: accounts of violence, harm reduction, and potential solutions. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2015;68:S241-S7.
67. Karandikar S, Próspero M. From Client to Pimp Male Violence Against Female Sex Workers. *Journal of interpersonal violence*. 2010;25(2):257-73.
68. Sherman SG, Footer K, Illangasekare S, Clark E, Pearson E, Decker MR. "What makes you think you have special privileges because you are a police officer?" A qualitative exploration of police's role in the risk environment of female sex workers. *AIDS care*. 2015;27(4):473-80.
69. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *American journal of public health*. 2003;93(6):939-42.
70. Meyer JP, Springer SA, Altice FL. Substance abuse, violence, and HIV in women: a literature review of the syndemic. *Journal of Women's Health*. 2011;20(7):991-1006.
71. Gilbert L, Raj A, Hien D, Stockman J, Terlikbayeva A, Wyatt G. Targeting the SAVA (substance abuse, violence, and AIDS) syndemic among women and girls: a global review of epidemiology and integrated interventions. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2015;69:S118-S27.
72. Decker MR, McCauley HL, Phuengsamran D, Janyam S, Seage GR, Silverman JG. Violence victimisation, sexual risk and sexually transmitted infection symptoms among female sex workers in Thailand. *Sexually Transmitted Infections*. 2010;86(3):236-40.
73. Swain SN, Saggurti N, Battala M, Verma RK, Jain AK. Experience of violence and adverse reproductive health outcomes, HIV risks among mobile female sex workers in India. *BMC Public Health*. 2011;11(1):357.
74. Shannon K, Kerr T, Strathdee SA, Shoveller J, Montaner JS, Tyndall MW. Prevalence and structural correlates of gender based violence among a prospective cohort of female sex workers. *BMJ*. 2009;339.
75. Singer M. A dose of drugs, a touch of violence, a case of AIDS: conceptualizing the SAVA syndemic. *Free Inquiry in Creative Sociology*. 1996;24(2):99-110.

4. Violence and HIV risk in Russian FSW

Abstract

Background: A multitude of studies have documented associations between violence and HIV risk among female sex workers (FSW). However, few studies comprehensively assess multiple major forms of violence and multiple major sources of HIV risk in the same study in order to build a global picture of how specific forms of violence are implicated in specific HIV risk pathways.

Methods: Using respondent-driven sampling, 754 FSW from Russia were recruited. Participants self-reported lifetime exposure to client, police, intimate partner, and pimp violence, as well as recent injecting drug use, inconsistent condom use with intimate partners, and inconsistent condom use with clients. Multivariate log-binomial and Poisson regression were used to assess associations between specific forms of violence and HIV risk outcomes.

Results: Sources of HIV risk were prevalent, with 10.7% recently injecting drugs, 45.1% engaging in inconsistent condom use with intimate partners, and 22.5% engaging in inconsistent condom use with clients. After adjusting for demographic confounders, intimate partner violence (IPV) and client violence were associated with injecting drug use (ARR_{IPV} 2.12, 95% CI 1.10, 4.10; ARR_{Client} 2.75, 95% CI 1.19, 6.32), IPV and police violence were associated with inconsistent condom use with intimate partners (ARR_{IPV} 1.10, 95% CI 1.01, 1.19; ARR_{Police} 1.11, 95% CI 1.01, 1.21), and IPV and police violence were associated with inconsistent condom use with clients (ARR_{IPV} 1.49, 95% CI 1.02, 2.17; ARR_{Police} 1.65, 95% CI 1.19, 2.29). Most associations attenuated when multiple forms of violence were included in the same model. In models that adjusted for all four forms of violence, only client violence (ARR 2.44, 95% CI 1.06, 5.60) was associated with drug use, and only police violence (ARR 1.47, 95% CI 1.09, 1.98) was associated with inconsistent condom use with clients at $p < 0.05$.

Conclusions: All sexual and drug-related HIV risk behaviors had multiple specific forms of violence associated with them, supporting the need for comprehensive violence prevention programming that takes

into account other types of violence beyond client violence. In particular, IPV and police violence were associated with all three HIV risk behaviors and represent under-studied forms of violence in the lives of FSW.

Introduction

More than 30 years into the HIV epidemic, in 2015 there were still 2.1 million incident infections and 1.1 million AIDS-related deaths globally.[1] Female sex workers (FSW) have been and continue to be a key population in the HIV epidemic, with indications that the sex trade is growing globally.[2] A systematic review of studies from 50 countries found that FSW have an average HIV prevalence of 11.8% and have 13.5 times higher odds of HIV infection than the overall population of adult women.[3]

Sources of HIV risk in FSW

The primary proximal causes of HIV infection among FSW are sexual risk from clients, sexual risk from non-clients, and injecting drug use (IDU). Sexual risk for FSW varies by the type of sex work, but sex work broadly involves a high number of partners with high concurrency, placing FSW at risk of HIV.[3] Intimate partners are a secondary, and understudied, source of HIV risk among FSW, as condom use among FSW globally is higher with clients than it is with intimate partners.[4, 5] Both clients and intimate partners of FSW are often higher risk partners than the general population of men, i.e. more likely to be living with HIV and engaging in HIV risk behaviors, which places FSW at greater risk of acquiring the virus.[6, 7]

In many areas of the world, there is a strong overlap between sex workers and people who inject drugs, as sex workers may initiate drug use to cope with trauma or job-related stress, and drug users may initiate sex work to help pay for drugs.[8] People who inject drugs are also a key population in the HIV epidemic, with an estimated 13% HIV prevalence globally in this population.[9] Data suggest that women who inject drugs may be more likely to be living with HIV than men who inject drugs, pointing to

gendered vulnerabilities to HIV and also to the large overlap with sex work populations.[10] FSW who inject drugs have higher levels of sexual HIV risk than their non-injecting counterparts in addition to their drug-related risk.[11, 12] In many global settings, FSW have high prevalence of injection drug use[13-17] and FSW who inject drugs are at heightened HIV risk.[6, 18-20]

Links between violence and HIV risk pathways

While unprotected sexual violence can directly transmit HIV, there are many other pathways between violence and HIV risk other than direct transmission during sexual violence that are arguably more important and account for more of the HIV burden generated by violence.[21] Extensive literature has elucidated mechanisms by which specific types of violence may lead to inconsistent condom use with clients. Client violence is often directly linked to condom use with clients, with clients directly enforcing non-condom use through violence, or FSW not using condoms out of fear of violence.[22-24] Intimate partners may use violence to push women to sell riskier sex to make more money, either becoming actively involved as a pimp or simply expecting women to bring in more money.[22, 25] Further, women may also engage in riskier, unprotected sex work to become financially independent from abusive partners.[26] Police violence is linked to inconsistent condom use with clients as carrying condoms can be used as evidence of engaging in sex work in many settings, leading FSW to choose not to keep condoms available or leading to police seizing condoms as evidence.[27] Police violence and harassment can also push sex workers more underground where they may be forced to take riskier or more violent clients who may be less likely to use condoms.[24, 25, 27] Pimp violence has been associated with inconsistent condom use with clients;[28] pimps may use violence to ensure FSW comply with demands for riskier, more highly paid sex acts such as unprotected vaginal or anal sex.[29]

Research focusing on condom use with non-paying partners among FSW has lagged behind research on FSWs' other sources of sexual and drug-related HIV risk, namely inconsistent condom use with clients and injecting drug use. The lack of attention to intimate partners in HIV research is in part

due to persistent myths that FSW do not have intimate partners.[30] Literature linking violence from intimate partners and inconsistent condom use with those partners is most robust due to the direct link, and comes from women in the general population as well as FSW.[31-34] Client violence has also been linked to inconsistent condom use with non-paying partners.[34, 35] In some settings, client violence is more associated with condom use in non-paying relationships than it is with condom use in paying relationships.[35] This is partially because in many settings, virtually all FSW report non-negotiable consistent condom use with clients, while consistent condom use with non-paying partners tends to be much less prevalent and therefore potentially more dependent on other factors.[35] Client violence may be associated with inconsistent condom use with intimate partners due to the non-specific trauma pathways described above, e.g. reducing self-efficacy. However, the extent to which apparent associations between client violence and inconsistent condom use with intimate partners is an artifact of sex workers being unable to distinguish between regular clients and non-paying partners is unclear.[35] Less still is known about the links between pimp or police violence and condom use with non-paying partners.

In longitudinal studies, there is a bidirectional link between intimate partner violence (IPV) and IDU, with drug use increasing women's vulnerability to violence, and violence increasing women's use of drugs.[36] In many settings, IDU and sex work are both illegal, and women who both sell sex and use drugs are further marginalized, socially isolated, and made vulnerable to work-related violence,[37] including police violence.[38] Arrest by police and placement in high-risk detention centers can expose FSW to a concentrated population of other women who use drugs and engage in needle sharing, increasing their likelihood of injecting and unsafe injection.[21, 39, 40] Client violence has been associated with IDU as a coping mechanism for trauma.[41] Pimps may also use violence to initiate or promote drug addiction among FSW[42] in order to increase their dependency, and pimp violence has been associated with other drug use as well.[43] In return, drug use can increase the likelihood of violence by disrupting cognition and impairing judgment, potentially making individuals more likely to enter violent situations and less able to skillfully deescalate dangerous situations.[36] FSW with drug addiction

also are more likely to take on more risk, including risk of violence, if necessary in order to finance buying drugs; FSW who do not need to purchase drugs can afford to turn down riskier clients.[14]

In addition to the pathways above by which specific forms of violence lead to both sexual and drug-related HIV risk behavior, there are psychosocial mediators between violence and HIV risk that are shared across the specific types of violence. In responding to violence and trauma, psychological outcomes that mediate sexual or drug-related HIV risk can be triggered, including depression, post-traumatic stress disorder (PTSD), and chronic stress responses.[44, 45] An individual may also use non-injecting drugs, such as alcohol, to cope with the effects of trauma. All of these trauma responses can increase the likelihood of both inconsistent condom use and IDU.[44, 45] Experiencing trauma can also reduce self-efficacy, which may reduce women's capacity for negotiating condom use and using condoms with clients or intimate partners. Sexual violence particularly has been noted to alter sexual behavior, including predisposing the survivor to either hyperarousal or sex avoidance, with implications for their exposure to sexual risk.[44, 45]

Previous analyses of this dataset

The current analysis builds on previous analyses of this dataset, which looked primarily at recent violence from clients, pimps, and police and their associations with biologically confirmed HIV infection and injecting drug use.

Decker and colleagues found that client violence in the past six months was consistently associated with HIV infection, including client physical violence (AOR 2.52, 95% CI 1.41, 4.51), client vaginal rape (AOR 3.77, 95% CI 1.73, 8.22), and client anal rape (AOR 4.80, 95% CI 1.89, 12.19).[46] HIV status was also associated with lifetime exposure to pimp violence (AOR 6.32, 95% CI 1.85, 21.63). The present analysis will build on this existing analysis in a number of ways. First, we examine IPV, which has frequently been overlooked in the literature as an important source of violence in FSWs' lives. Second, the existing analysis by Decker and colleagues do not look at the independent effects of violence

when taking into account other forms of violence;[46] in our analyses we build a series of models that adjusts for other types of violence experienced. Third, the existing analysis only looked at associations with biologically confirmed HIV infection, and not with HIV risk behaviors. While HIV status is an informative outcome, it does not shed light on the intermediate steps in the pathway of how specific types of violence may lead to FSW contracting HIV, via primary risk pathways of unprotected sex with different partners or IDU.

Another analysis of this dataset by Wirtz and colleagues looked closely at injecting behaviors and associations with sexual and structural HIV risks, including violence.[12] All FSW who used drugs reported using a shared needle or syringe at least sometimes and half reported doing it “always or often.” Recent IDU, as compared to never having injected drugs, was associated with recent sexual violence from police (AOR 3.2, 95% CI 1.2, 8.7), recent physical violence from clients (AOR 7.3, 95% CI 2.1, 24.7), and recent sexual violence from clients (AOR 3.3, 95% CI 1.5, 7.1).[12] FSW who formerly injected drugs but who had not injected in the past 6 months had a similar sexual and structural HIV risk profile to FSW who never injected, and had a much lower prevalence of police and client violence than did current injectors. This supports our decision in the present analysis to look at current IDU as an outcome and combining former use and never use in the comparison group. The current analysis builds on the analysis by Wirtz and colleagues by examining IPV and pimp violence in addition to client and police violence and by focusing on lifetime exposure to violence rather than recent violence.

In this analysis we look at three major sources of HIV risk: IDU, inconsistent condom use with clients, and inconsistent condom use with intimate partners. For each outcome, we examine the associations with major forms of violence against FSW in this setting: client violence, police violence, intimate partner violence, and police violence.

Methods

Study Setting

Russia is a unique and complex setting for understanding violence and HIV in the context of sex work. Russia is one of just a few countries in the world where HIV prevalence and incidence are still increasing.[47-50] Russia has the highest incidence in Europe; incident infections have risen on average almost 11% per year in the last decade, rising from 39,402 infections in 2005 to 98,177 in 2015.[51] Russia is transitioning toward a heterosexual contact-driven HIV epidemic from an injecting drug use-driven epidemic, particularly among women. In 2008, 63% of incident infections among women were due to sexual contact,[52] a number that may be increasing through time: only 18.7% of new infections among women in 2015 were due to injecting drug use.[50]

Since 2012, foreign and multilateral donors have left or been ejected from the country, and the Russian government has not funded FSW-focused programs.[53] IDU is common among Russian FSW, with estimates including 17.7% lifetime use in Moscow[29] and 47.5% past-day use in St. Petersburg and Orenburg.[54] Recent research demonstrates prevalent physical and sexual violence against FSW.[29, 46, 54] HIV is prevalent among FSW, particularly among those who inject drugs. In the parent study prevalence was 6.4%, 3.6%, and 1.6% in Kazan, Krasnoyarsk, and Tomsk, respectively, or 3.9% overall.[46] Earlier estimates from other cities showed an HIV prevalence among FSW ranging from 4.8% in Moscow[29] in 2005 to 48.1% among FSW who inject drugs in St. Petersburg in 2003 [55]. The Russian government does not provide nationwide, FSW-specific surveillance figures.[50] Sex work is criminalized in Russia and punishable by a fine of 2000 rubles (\$60) while drug use is punishable with punitive detoxification programs, fines, or imprisonment.[56]

Kazan is the eighth largest city in Russia and is 500 miles east of Moscow. Tomsk and Krasnoyarsk are located in Siberia. Tomsk (population 524,669) is the smallest, least industrial site and boasts several universities. Krasnoyarsk (population 1,035,528) is an industrial center located along the

Trans-Siberian railway; historically, Krasnoyarsk was the site of a gulag forced labor camp. All cities have significant sex work industries. Women typically recruit clients on the street, in saunas, in hotels, online, or from *tochkas* (areas along streets where sex workers gather and meet clients out of cars). The number of sex workers in Russia is thought to be steadily on the rise due to economic pressures, including globalization, increasing unemployment, migration from rural to urban areas in search of work, and continuing ripples felt from the massive economic transition after the fall of the Soviet Union and from the recent financial crisis.[2]

Data collection

Data were collected in 2011 from a sample of n=754 FSW from Tomsk, Kazan, and Krasnoyarsk, Russia as part of a large-scale program evaluation for Global Fund program activities, Global Efforts Against HIV/AIDS in Russia (GLOBUS).[46] The primary objective was to evaluate GLOBUS by assessing program coverage, HIV knowledge, risk behaviors, condom use, and HIV prevalence among FSW. The survey collected detailed data on sex work context, including exposure to violence.

Study recruitment and eligibility

Recruitment was via respondent-driven sampling (RDS)[57] at each site, with respondents given 5 recruitment coupons each. RDS was chosen due to the difficulty of creating a sampling frame and using random sampling in a hard-to-reach population.[57] Individuals were eligible for the study if they were non-transgender women, at least 18 years old, worked or resided in one of the three cities, and had exchanged sex for money, drugs, or shelter in the past 3 months. Seeds were purposively selected by local partners to maximize diversity, including street and off-street sex work and injecting and non-injecting FSW. Study interviewers were local Russian non-governmental organization (NGO) staff trained by Johns Hopkins University staff. Interviews in Tomsk and Krasnoyarsk took place in the local NGO's office; in Kazan interviews were also conducted in a mobile unit at locations across the city due to the remoteness of the local office. Verbal informed consent was used to protect confidentiality. Interviews

were self-administered on a computer and took 20-30 minutes, followed by OraQuick HIV testing. Women received a small gift (<\$5USD) for participation. The study was approved by Open Health Institute in Moscow, Russia and considered exempt as public health practice by the Johns Hopkins School of Public Health Institutional Review Board. The current secondary analysis of existing, de-linked, deidentified data was considered not human subjects research by the same IRB. Further details are published elsewhere.[46]

Exposure measures: violence from intimate partners, clients, pimps and police.

The violence exposures are lifetime exposure to intimate partner violence (physical), client violence (physical or sexual), pimp/momka violence (physical or sexual), and police violence (sexual) (See Table 1). Extensive formative research identified these types of violence as most relevant in the lives of FSW in this setting. Measures are based on the Conflicts Tactics Scale 2 (CTS-2) which asks about specific behaviors rather than asking about abuse generally,[58] the standard in the field.[59] The CTS-2 has been validated in diverse samples and adapted to sex work populations.[60, 61] Formative research also informed development of more setting-specific behaviors, such as common types of physical abuse from pimps or momkas and asking about *subbotnik*, or coerced sex with police officers in order to avoid arrest.[46]

Table 4.1: Survey items measuring violence victimization exposures of interest.

Source	Measure
Intimate partner	Think about your boyfriends, husband, or other people you have dated. Have you been hit, pushed, slapped, or otherwise physically hurt by a boyfriend, husband, or someone you were dating?
Client	Have you been hit, pushed, slapped, or otherwise physically hurt by a client?
	Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a client?
	Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>vaginal</i> sex when you didn't want to?

	Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>anal</i> sex when you didn't want to?
Pimp/momka	Have you been hit, pushed, slapped, or otherwise physically hurt by a pimp/momka?
	Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a pimp/momka?
	Has your pimp ever forced you to have sex when you did not want to?
Police	How many times have you been involved in a subbotnik (asked to provide sex to police or militia to avoid incarceration or arrest)?
	In the past 6 months, have you had to pay or compensate the police for the ability to sell sex or stand on the street? Options include: Yes, had to provide sex

There were two additional client violence measures available in the survey specific to pressured or coerced vaginal or anal sex: “Have you had a client pressure you for or insist on *vaginal* sex when you did not want to (but did not use physical force)” and “Have you had a client pressure you for or insist on *anal* sex when you did not want to (but did not use physical force).” Because there were not measures on pressured or coerced sex for any other type of perpetrator, these two items were not used in the main analysis. The 4-item assessment was used in the main analysis to enhance comparability across perpetrators. A sensitivity analysis was undertaken comparing the results of the 4-item assessment with the available 6-item assessment for client violence. Results using the 6-item definition of client violence (inclusive of sexual coercion) were qualitatively similar to results using the 4-item definition restricted to forced sex. We therefore proceed below with the 4-item measure.

The following covariates are included as potential confounders based on a review of the literature and bivariate association with at least one type of violence at $p < 0.1$: age,[62, 63] engaging in street-based sex work (binary),[38, 54, 64-66] average number of vaginal or anal sex clients per night,[29] having another income besides sex work,[12, 65] current number of non-paying intimate partners,[33] duration of time in sex work,[12] education level,[67] age of entry into sex work,[42, 68] relationship status (categorical),[12, 69] and monthly salary.[70]

Outcome variables

Three outcome variables were examined. Outcome measures are current or within the past six months.

The drug-related HIV risk outcome is injecting drugs in the past 6 months. Respondents were asked “Have you ever used a needle to inject drugs?” and given the options of “Yes, in the past 6 months,” “Yes, not in the past 6 months, but before that,” and “No.” Given the high levels of injecting drug use among FSW in the Russian context,[54] this is a key source of HIV risk. In this dataset, over half the women who have used drugs in the past 6 months also reported sharing syringes during that time frame.[12] While syringe sharing is arguably a more specific HIV risk outcome, injecting drug use is also a valid HIV risk behavior, was more prevalent and so provided greater power for statistical analyses, and may be less subject to systematic reporting biases or recall reliability issues (i.e. there are likely some FSW who reported that they injected but either did not remember or were unwilling to report sharing syringes).[71]

The sexual HIV risk outcomes are 1) inconsistent condom use with clients in the past 6 months; and 2) inconsistent condom use with current main non-paying sex partner (i.e. intimate partner). Respondents were asked “Over the past 6 months, how often do you use a condom with clients during vaginal sex?” and “Over the past 6 months, how often do you use a condom with clients during anal sex?” and given response options of always, often, half the time, sometimes, rarely, and never. Participants who responded “always” to both questions were considered consistent condom users with clients; otherwise they were considered to have the outcome of inconsistent condom use with clients. To assess inconsistent condom use with an intimate partner, participants were asked to think of their current main nonpaying sexual partner and asked “How often do you use condoms with this partner?” Participants who stated that they “always” use condoms were considered consistent condom users with their intimate partner; otherwise they were considered to have the outcome of inconsistent condom use with their intimate partner. Assessing condom usage with clients is one of the UNAIDS core indicators.[72] Unprotected sex

with intimate partners is an important HIV risk source given higher frequency of unprotected sex with intimate partners as compared to clients[5, 73] and association of having an intimate partner with HIV risk for FSW.[4, 33, 74]

Missing data

Multiple imputation with chained equations was used to impute missing data. The amount of missing data for each variable used in the analysis ranged from 0.3% to 10.4%; intimate partner violence was the only variable missing more than 10% of values. Approximately 16% of the sample was missing at least one of the four key violence exposure variables (0.4% for pimp violence, 2.1% for police violence, 7.6% for client violence, and 10.4% for intimate partner violence). Key exposure variables, variables indicating recruitment cluster membership, potential demographic confounders, and all variables found to be associated with key exposure variables or associated with missingness in those variables, were identified for inclusion in the imputation model. Because of difficulties with model convergence due to the number of variables, variables that were missing less than 2% of values were imputed using the mean or mode of respondents in the same recruitment chain. The remaining variables were imputed via multiple imputation with 20 multiply imputed datasets.

Analyses

Data were collected using respondent-driven sampling (RDS), including provision of recruitment coupons and tracking of recruitment chains. However, participants were unable to answer questions about network size, and therefore RDS-adjusted statistics could not be calculated. All regressions are performed with complex survey adjustment for intracluster correlation by strata (city) and cluster (recruitment chain).

The goal of this analysis was to understand what types of violence have the strongest associations with each outcome, in order to build a holistic picture of how specific types of violence are implicated in specific HIV risk pathways. Three outcomes were chosen to build a holistic picture of multiple major forms of HIV risk in the population. Because there are three outcomes (injecting drug use, inconsistent condom use with intimate partner, and inconsistent condom use with clients), the same analytic steps were repeated for each outcome. First, we use cross-tabulations to understand the prevalence of each outcome among those unexposed and exposed to each type of violence. Using bivariate log-binomial regression, we then determine the unadjusted risk ratio between each of the health outcomes and each type of violence (Model 1). We then build a second series of models that adjust for potential demographic and sex work context confounders only (Model 2). Finally, we use multivariate log-binomial regression, including all four violence exposures and the same set of potential confounders included in Model 2 in the model, to calculate the independent association of each type of violence for each outcome (Model 3).

Model 2 may be of greatest interest for informing interventions, as it is likely the best suited model for estimating the total effect of a specific form of violence on an HIV risk outcome. While adjusting for confounders decreases bias, adjusting for mediators causes overadjustment bias toward the null by estimating only the direct, unmediated effect of the exposure on the outcome.[75] This type of bias is likely an issue in Model 3. For instance, if we believe that pimp violence is a confounder of the relationship between client violence and injecting drug use, that would make client violence by definition a mediator of the relationship between pimp violence and drug use. Including both client violence and pimp violence in the same model, as we do in Model 3, would underestimate the total effect of pimp violence on drug use. Given our four violence exposures of interest and the degree of association found between them in Aim 1, it would be difficult to draw a causal diagram in which no forms of violence serve as a partial mediator between another form of violence and an HIV risk outcome. Typically the total effect (including the effect passing through the mediator) is of greatest public health interest, making results from Model 2 relevant in considering potential violence targets for interventions.[75] Because of

strong correlations between types of violence as demonstrated in Aim 1, multicollinearity between types of violence in Model 3 may also lead to Model 3 being underpowered, decreasing precision.

Despite these caveats, Model 3 is also useful. This model will have fewer issues with confounding than Model 2 and is best positioned to clarify which types of violence have a strong, direct, independent effect on each outcome. Many studies of violence against FSW do not distinguish between perpetrators or only measure violence by one type of perpetrator,[41, 68, 76-78] so models that adjust for multiple types of violence are uncommon. Results from model 3 are thus a relatively novel contribution to the literature.

Regression models with the outcome of inconsistent condom use with intimate partners only used FSW who reported having a current intimate partner (N=431) rather than the full sample (N=754), as only this subset was at risk for the outcome. Poisson models were used when log-binomial models did not converge.

Results

The sexual HIV risk outcomes of inconsistent condom use with intimate partners (78.9% among the 57% of the sample with an intimate partner) and inconsistent condom use with clients (22.5%) were more common than injecting drug use (10.7%) (Table 2).

Table 4.2: Prevalence of recent HIV risk behaviors

	N	Prevalence (%)
Injecting drug use (past 6 months)	754	10.7
Inconsistent condom use with current main intimate partner – among those with intimate partner(s)	431	78.9
Inconsistent condom use with current main intimate partner(s) – in the whole sample*	754	45.1
Inconsistent condom use with clients (past 6 months)	754	22.5

*Provided for reference; this is not used as an outcome variable in regression models. All regression models with inconsistent condom use with intimate partners are restricted to individuals reporting a current intimate partner.

In fully adjusted models (Table 3, Model 3), client violence was the only type of violence associated with IDU (adjusted risk ratio (ARR) 2.44, 95% confidence interval (CI) 1.06, 5.60). However, in bivariate models (Table 3, Model 1), client violence (relative risk (RR) 2.80, 95% CI 1.19, 6.59), police violence (RR 2.86, 95% CI 1.77, 4.60), and IPV (RR 2.32, 95% CI 1.34, 4.02) were all associated with IDU. These associations remained significant or marginally significant in Model 2 adjusted for demographics but not for other violence exposures.

Inconsistent condom use with intimate partners was not significantly associated with any type of violence in fully adjusted models (Table 3, Model 3), although police violence (ARR 1.09, 95% CI 0.98, 1.21) and IPV (ARR 1.08, 95% CI 0.98, 1.18) were marginally associated with this outcome. However, in bivariate models (Table 3, Model 1), all four types of violence are significantly associated with inconsistent condom use with intimate partners: client violence (RR 1.10, 95% CI 1.00, 1.21), police violence (RR 1.16, 95% CI 1.04, 1.29), IPV (RR 1.12, 95% CI 1.03, 1.23), and pimp violence (RR 1.09, 95% CI 1.00, 1.19). These associations attenuate with the inclusion of demographic and sex work context factors in the model (Table 3, Model 2), but police violence (ARR 1.11, 95% CI 1.01, 1.21) and IPV (ARR 1.10, 95% CI 1.01, 1.19) remain marginally significant.

In fully adjusted models, police violence is the only type of violence associated with inconsistent condom use with clients (Table 3, Model 3; ARR 1.47, 95% CI 1.09, 1.98). In bivariate models (Table 3, Model 1), police violence is still the only type of violence associated with inconsistent condom use with clients (RR 2.11, 95% CI 1.29, 3.45). In models adjusted only for demographics and sex work context (Table 3, Model 2), inconsistent condom use with clients is associated with intimate partner violence (ARR 1.49, 95% CI 1.02, 2.17) and police violence (ARR 1.65, 95% CI 1.19, 2.29), and it is marginally associated with pimp violence (ARR 1.57, 95% CI 0.98, 2.51).

Table 4.3: Crude and adjusted relationships between lifetime violence and HIV risk (N=754 except where indicated)

Outcome	Exposure	Prevalence of the outcome among exposed (%)	Prevalence of the outcome among unexposed (%)	Model 1: Bivariate relative risk (RR) (95% CI)	Model 2: ARR (95% CI) adjusted for demographics and sex work context variables only ¹	Model 3: ARR (95% CI) adjusted for other types of violence, demographics, and sex work context ²
Injecting drug use N=754	Client	19.1	6.8	2.80 (1.19, 6.59)*	2.75 (1.19, 6.32)*	2.44 (1.06, 5.60)*
	Police	23.7	8.3	2.86 (1.77, 4.60)***	1.72 (1.00, 2.96)^	1.27 (0.81, 1.99)
	IPV	20.7	8.9	2.32 (1.34, 4.02)**	2.12 (1.10, 4.10)*	1.50 (0.80, 2.80)
	Pimp	15.1	10.2	1.48 (0.73, 3.01)	0.96 (0.50, 1.86)	0.58 (0.31, 1.10)
Inconsistent condom use with intimate partners N=431	Client	83.9	76.4	1.10 (1.00, 1.21)*	1.05 (0.97, 1.15)	1.01 (0.91, 1.12)
	Police	88.6	76.6	1.16 (1.04, 1.29)**	1.11 (1.01, 1.21)*	1.09 (0.98, 1.21)^
	IPV	86.5	77.1	1.12 (1.03, 1.23)*	1.10 (1.01, 1.19)*	1.08 (0.98, 1.18)^
	Pimp	85.2	78.0	1.09 (1.00, 1.19)*	1.03 (0.95, 1.12)	1.00 (0.91, 1.09)
Inconsistent condom use with clients N=754	Client	25.6	21.1	1.21 (0.57, 2.58)	1.40 (0.89, 2.21)	1.10 (0.67, 1.79)
	Police	40.4	19.1	2.11 (1.29, 3.45)**	1.65 (1.19, 2.29)**	1.47 (1.09, 1.98)*
	IPV	30.0	21.2	1.42 (0.79, 2.55)	1.49 (1.02, 2.17)*	1.26 (0.89, 1.80)
	Pimp	28.0	21.8	1.28 (0.82, 2.00)	1.57 (0.98, 2.51)^	1.30 (0.78, 2.19)

^ <0.1, * <0.05, **<0.01, ***<=0.001

¹ Adjusted for participation in street sex work, average number of vaginal or anal sex clients per day, having another source of income besides sex worker, number of current intimate partners, number of years in sex work, educational level, age of entry into sex work, relationship status, and monthly salary.

² See Table 4 for full model results. Models include all four types of violence experienced and also adjusts for the same variables as Model 2, i.e. participation in street sex work, average number of vaginal or anal sex clients per day, having another source of income besides sex worker, number of current intimate partners, number of years in sex work, educational level, age of entry into sex work, relationship status, and monthly salary.

Table 4 presents complete details of the fully adjusted Model 3 from Table 3, including association of demographic and sex work context variables with the outcomes. In fully adjusted models (Table 4), IDU was also associated with older age (ARR 1.08, 95% CI 1.00, 1.16) and inversely

associated with having another income besides sex work (ARR 0.39, 95% CI 0.15, 0.99), having intimate partner(s) (ARR 0.54, 95% CI 0.34, 0.99), and being legally married or widowed (ARR 0.17, 95% CI 0.05, 0.62). There were no significant demographic or sex work context correlates of inconsistent condom use with intimate partners. Inconsistent condom use with clients was inversely associated with the average number of vaginal or anal sex partners per night (ARR 0.69, 95% CI 0.57, 0.85), being legally married or widowed (ARR 0.24, 95% CI 0.08, 0.71), and monthly salary (ARR 0.99, 95% CI 0.98, 1.00).

Table 4.4: Fully adjusted multivariate models for HIV risk outcomes, showing ARR for lifetime violence exposure, demographic factors, and sex work context variables

	Injecting drug use ARR (95% CI)	Inconsistent condom use with intimate partners ARR (95% CI)	Inconsistent condom use with clients (ARR 95% CI)
Client	2.44 (1.06, 5.60)*	1.01 (0.91, 1.12)	1.10 (0.67, 1.79)
Police	1.27 (0.81, 1.99)	1.09 (0.98, 1.21)	1.47 (1.09, 1.98)*
IPV	1.50 (0.80, 2.80)	1.08 (0.98, 1.18)	1.26 (0.89, 1.80)
Pimp	0.58 (0.31, 1.10)	1.00 (0.92, 1.09)	1.30 (0.78, 2.19)
Age	1.08 (1.00, 1.16)*	1.01 (0.99, 1.02)	0.97 (0.91, 1.04)
Any street SW	2.39 (0.67, 8.51)	1.11 (0.99, 1.26)	1.35 (0.86, 2.12)
Avg # of vaginal or anal sex partners per night ¹	0.81 (0.65, 1.01)	0.98 (0.94, 1.02)	0.69 (0.57, 0.85)***
Other income besides sex work	0.39 (0.15, 0.99)*	1.02 (0.90, 1.16)	1.37 (1.03, 1.84)*
Current number of intimate partners ²	0.54 (0.34, 0.99)*	0.83 (0.67, 1.02)	1.06 (0.74, 1.50)
Sex work duration ³	1.15 (0.84, 1.57)	1.01 (0.97, 1.05)	1.03 (0.93, 1.16)
Education	0.84 (0.62, 1.14)	1.03 (0.97, 1.10)	1.02 (0.88, 1.18)
Age of entry ⁴	0.95 (0.85, 1.06)	0.98 (0.96, 1.00)	1.02 (0.95, 1.09)
Relationship			
Never married	Ref	Ref	Ref
Dating someone	0.76 (0.27, 2.18)	1.08 (0.85, 1.36)	0.88 (0.62, 1.26)

Living together	1.07 (0.63, 1.82)	1.20 (0.94, 1.54)	0.98 (0.63, 1.54)
Legally married or widowed	0.17 (0.05, 0.62)**	0.96 (0.67, 1.38)	0.24 (0.08, 0.71)*
Divorced or separated	0.71 (0.37, 1.39)	1.16 (0.82, 1.63)	0.90 (0.61, 1.34)
Monthly salary in 1000s rubles	0.99 (0.97, 1.01)	1.00 (1.00, 1.00)	0.99 (0.98, 1.00)*

¹ Ordered categorical variable with response options 0, 1, 2, 3, or more than 3

² Ordered categorical variable with response options 0, 1, or 2 or more

³ Ordered categorical variable with response options 6 months or less, 6 months to 1 year, 1-2 years, 2-3 years, 3-4 years, more than 4 years

⁴ Continuous

Discussion

In models adjusted for all other types of violence experienced as well as potential confounders (Model 3), we found just two significant associations: between client violence and injecting drug use (ARR 2.44, 95% CI 1.06, 5.60) and between police violence and inconsistent condom use with clients (ARR 1.47, 95% CI 1.09, 1.98). However, in models that were adjusted for demographic and sex work context factors but not for other forms of violence (Model 2), intimate partner violence (IPV) and client violence were associated with injecting drug use (ARR_{IPV} 2.12, 95% CI 1.10, 4.10; ARR_{Client} 2.75, 95% CI 1.19, 6.32), IPV and police violence were associated with inconsistent condom use with intimate partners (ARR_{IPV} 1.10, 95% CI 1.01, 1.19; ARR_{Police} 1.11, 95% CI 1.01, 1.21), and IPV and police violence were associated with inconsistent condom use with clients (ARR_{IPV} 1.49, 95% CI 1.02, 2.17; ARR_{Police} 1.65, 95% CI 1.19, 2.29). There were additional marginal associations between injecting drug use and police violence (ARR 1.72, 95% CI 1.00, 2.96), and between inconsistent condom use with clients and pimp violence (ARR 1.57, 95% CI 0.98, 2.51). These models that do not adjust for other types of violence experienced reveal a much broader range of types of violence were associated with HIV risk outcomes than indicated in models that also adjust for other types of violence experienced. As discussed in the Methods section, results from Model 2 may more accurately estimate the total effect of a specific form of violence on the HIV risk outcome by reducing overadjustment bias toward the null caused by

adjusting for violence mediators[75] and power issues caused by multicollinearity between types of violence.

Findings from Model 2 emphasize the importance of comprehensive violence prevention in HIV prevention that addresses violence from multiple perpetrators. For sexual risk outcomes, that means addressing violence from other individuals besides the individual with whom unprotected sex is occurring. For instance, interventions to address inconsistent condom use with clients often address violence from clients based on extensive literature documenting the links between client violence and client non-condom use.[22-24] In our sample, police (ARR 1.65, 95% CI 1.19, 2.29), intimate partner (ARR 1.49, 95% CI 1.02, 2.17), and pimp (ARR 1.57, 95% CI 0.98, 2.51) violence are more strongly associated with this HIV risk pathway than is client violence itself (ARR 1.40, 95% CI 0.89, 2.21). Similarly, not only is IPV implicated in inconsistent condom use with intimate partners (ARR 1.10, 95% CI 1.01, 1.19), but so is police violence (ARR 1.11, 95% CI 1.01, 1.21). Interventions among FSW to prevent inconsistent condom use with intimate partners should therefore not only consider IPV but also police violence. Both client violence and intimate partner violence were associated with IDU. FSW often use drugs with clients[46, 79] or with intimate partners,[80, 81] which may explain this finding.

The strongest associations, which persisted in fully adjusted models that also accounted for other types of violence experienced (Model 3), were between client violence and injecting drug use (ARR 2.44, 95% CI 1.06, 5.60) and between police violence and inconsistent condom use with clients (ARR 1.47, 95% CI 1.09, 1.98). One likely mechanism for a link between client violence and injecting drug use is FSW drug use to cope with trauma.[41] There are also plausible causal mechanisms in the other direction, with injecting drug use leading to client violence. In these Russian cities, pimps and protection gangs are often unwilling to work with FSW who inject drugs. While working with pimps and protection gangs often carries its own set of risks, it does offer some protection from client violence that most women who are injecting cannot access.[12] Women who need money for drugs often take on a much higher client volume (as evidenced in formative qualitative work from this study[46]) and therefore may take on riskier

and potentially more violent clients. Previous analyses from this dataset found that FSW who were current injecting drug users had a much higher proportion of clients who asked for anal sex and were more likely to not use a condom during vaginal or anal sex, as compared to FSW who formerly injected and FSW who had never injected.[12] They were also more likely to have experienced recent physical or sexual violence from clients.[12] Our results show they are also more likely to have experienced lifetime violence.

The finding that police violence was associated with inconsistent condom use with clients builds on literature showing that police violence drives FSW to work in more inconspicuous areas with less police presence, but also higher risk of violence for women because there are fewer other FSW or informal security networks nearby.[24, 25, 82] Women may feel pressured to accept condom non-use from clients or risk violence in these settings. Further, condoms may be taken as evidence of prostitution by police. In areas where police routinely harass or abuse FSW, FSW may choose not to carry condoms in order to prevent arrest.[27]

Inconsistent condom use with intimate partners was the most prevalent HIV risk behavior at 45.1% in the overall sample. Given the high prevalence of inconsistent condom use with intimate partners, and the finding that intimate partner violence was associated with injecting drug use (ARR 2.12, 95% CI 1.10, 4.10), inconsistent condom use with intimate partners (ARR 1.10, 95% CI 1.01, 1.19) and inconsistent condom use with clients (ARR 1.49, 95% CI 1.02, 2.17), intimate partners were a particularly significant source of HIV risk in this sample. Relationships between FSW and their intimate partners should be prioritized for violence and HIV prevention.

Patterns across outcomes

Examining multiple forms of violence and HIV risk outcomes allows us to ask two questions that are not possible to ask in studies that only consider a single type of violence or HIV risk behavior. First,

which outcomes are most consistently associated with multiple forms of violence? Secondly, which types of violence are most consistently associated with multiple HIV risk outcomes?

Table 4.5: Graphical summary of significant associations between specific types of violence and HIV risk outcomes

	IDU	Inconsistent condom use with intimate partners	Inconsistent condom use with clients
Client violence	*	*	
Police violence			*
IPV	*		*
Pimp violence		*	

Key

	Not associated with the outcome in any model
	Associated $p < 0.1$ in bivariate model (Model 1)
	Associated $p < 0.1$ in model adjusted for demographics and sex work context (Model 2)
	Associated $p < 0.1$ in fully adjusted model, adjusted for all types of violence experienced, demographics, and sex work context (Model 3)
*	Significant in that model at $p < 0.05$

To address the first question, all three HIV risk outcomes were associated with two to three forms of violence (Table 5). Therefore, no one particular outcome appeared to be particularly consistently driven by more types of violence. Rather, all three HIV risk outcomes were associated with multiple forms of violence and could benefit from comprehensive violence prevention programming that addresses violence from multiple perpetrators.

To address the second question, distinct patterns emerge showing that some forms of violence are more consistently associated than others with multiple HIV risk outcomes. Identifying types of violence

that are associated across multiple HIV risk outcomes would suggest that intervening on these specific types of violence may yield dividends in reducing multiple HIV risk pathways. Police violence and intimate partner violence were significantly or marginally associated with all three HIV risk behaviors in partially or fully adjusted models, while client violence was only significantly associated with injecting drug use and associated in bivariate models with inconsistent condom use with intimate partners. Lifetime pimp violence was only associated with inconsistent condom use with intimate partners in bivariate models and marginally associated with inconsistent condom use with clients in partially adjusted models, indicating that it likely does not play as large of a role in propagating either sexual or drug-related HIV risk in this population. This heterogeneity between different types of violence underscores that violence writ large, or examining only one type of violence in particular, is not sufficient to fully understand what forms of violence are or are not relevant for specific HIV risk pathways. Client violence, which is probably the most-researched form of violence among FSW, is only significantly associated with injecting drug use in adjusted models, while intimate partner violence, one of the least-researched forms of violence among FSW, is associated with all three HIV risk behaviors.

These findings suggest HIV prevention programming for FSW needs to broaden its focus to more consistently consider not just “work-related” violence like client or pimp violence, but also confront “structural” violence from state actors and address violence in FSWs’ intimate relationships. These issues are starting to gain more attention, with the first major cluster randomized trial of an IPV prevention intervention underway in Karnataka State, India with FSW as of 2016.[83] Additionally, there is recent work in this setting to build partnerships between police and FSW to reduce police violence.[84]

Limitations

Limitations of this study include the cross-sectional design. Longitudinal data would help establish temporality and narrow down potential causal mechanisms for the patterns observed in the

study. Measurement limitations include inconsistencies in how different types of violence were assessed in the survey, with client violence likely being the most sensitive measure; police were not assessed as potential physical violence perpetrators and intimate partners were not assessed as potential sexual violence perpetrators. There were also some limitations to our assessment of HIV risk outcomes. For instance, the survey item for inconsistent condom use with an intimate partner assumed the respondent has a single intimate partner, though women may have multiple partners. More work is needed to understand how lifetime versus recent violence exposure are differently associated with HIV risk. We chose to use lifetime exposures rather than recent exposures to violence as we conceptualized multiple forms of violence accumulating over the life course, placing an increasing cumulative burden on FSWs' health. However, it is possible that some of the null associations found between specific types of violence and specific HIV risk pathways might be due to *lifetime* violence having a weak effect on recent risk behaviors but *recent* violence having a stronger effect. In particular, the null association between client violence and inconsistent condom use with clients is at odds with a large body of literature.[22-24] One explanation would be that remote client violence may have little impact on recent condom use with clients.

More research is needed to build larger datasets or use analytic tools beyond standard multivariate regression analyses to understand the impact of multiple forms of violence on HIV risk. Even with a relatively large sample size of 754 individuals, multicollinearity between violence types reduces power to detect significant associations between individual violence types and HIV risk outcomes and to understand the independent contribution of each type of violence to HIV risk in Model 3. In the next chapter, we use linear and quadratic dose-response analyses to obviate the multicollinearity issue and examine how HIV risk increases as the number of types of violence accumulate. Models that include a single form of violence and adjust only for demographic confounders and sex work context variables (Model 2) also obviate issues with multicollinearity between violence types and are in line with previous analyses in the violence and HIV literature.[12, 24, 46, 54] As discussed in the methods

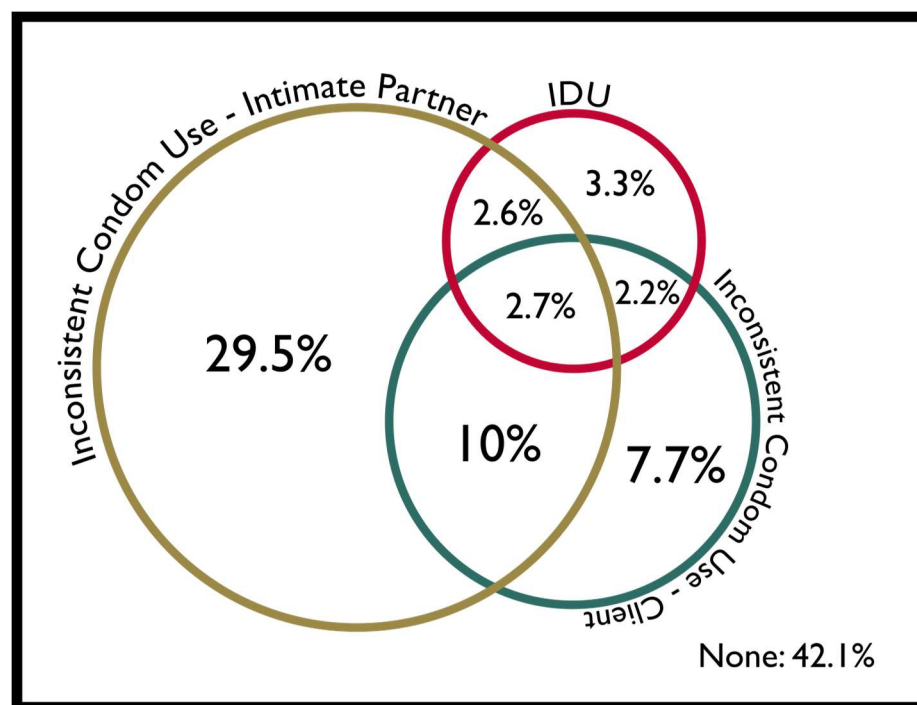
section, models of this form are appropriate when some types of violence may serve as a mediator between other types of violence and the outcome. Other techniques such as structural equation modeling may be informative in future work.

Conclusion

This study is the first to our knowledge to assess four forms of violence and three HIV risk pathways to build a comprehensive picture of how multiple forms of violence are implicated in various avenues of HIV acquisition among FSW. Evidence that IPV and police violence were associated with all three HIV risk outcomes increases the urgency of calls to address these understudied forms of violence against FSW. Findings show that multiple forms of violence are implicated in each of the HIV risk pathways, underscoring the need for addressing violence from multiple perpetrators in interventions that seek to reduce drug-related or sexual HIV risk in FSW. Findings also suggested which types of violence are most important to address in each of the three transmission pathways. As calls for comprehensive violence prevention programming for FSW[59] are increasingly implemented, similar comprehensive HIV and violence assessments should be carried out in other settings to guide interventions.

Appendix

Figure 4.A1: Proportional Venn diagram showing overlap between HIV risk outcomes (N=754)



References

1. UNAIDS. Fact sheet November 2016. Global HIV statistics. 2016.
2. Ward H, Aral S. Globalisation, the sex industry, and health. *Sexually transmitted infections*. 2006;82(5):345-7.
3. Baral S, Beyrer C, Muessig K, Poteat T, Wirtz AL, Decker MR, et al. Burden of HIV among female sex workers in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet infectious diseases*. 2012;12(7):538-49.
4. Voeten H, Egesah O, Varkevisser C, Habbema J. Female sex workers and unsafe sex in urban and rural Nyanza, Kenya: regular partners may contribute more to HIV transmission than clients. *Tropical Medicine & International Health*. 2007;12(2):174-82.
5. Deering KN, Bhattacharjee P, Bradley J, Moses SS, Shannon K, Shaw SY, et al. Condom use within non-commercial partnerships of female sex workers in southern India. *BMC public health*. 2011;11(Suppl 6):S11.
6. Rusakova M, Rakhmetova A, Strathdee SA. Why are sex workers who use substances at risk for HIV? *The Lancet*. 2014.

7. Patterson TL, Goldenberg S, Gallardo M, Lozada R, Semple SJ, Orozovich P, et al. Correlates of HIV, STIs and associated high risk behaviors among male clients of female sex workers in Tijuana, Mexico. *AIDS* (London, England). 2009;23(13):1765.
8. Rekart ML. Sex-work harm reduction. *The Lancet*. 2006;366(9503):2123-34.
9. UNAIDS. The Gap Report. http://www.unaids.org/sites/default/files/media_asset/UNAIDS_Gap_report_en.pdf: 2014.
10. Larney S, Mathers BM, Poteat T, Kamarulzaman A, Degenhardt L. Global Epidemiology of HIV Among Women and Girls Who Use or Inject Drugs: Current Knowledge and Limitations of Existing Data. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2015;69:S100-S9.
11. Tang Z, Zhang C, Li X, Liu Y, Su S, Zhou Y, et al. HIV risk among female sex workers with different patterns of drug use behaviors in Southwest China: a cross-sectional study. *AIDS care*. 2014;(ahead-of-print):1-8.
12. Wirtz A, Peryshkina A, Moguilnyi V, Beyrer C, Decker M. Current and recent drug use intensifies sexual and structural HIV risk outcomes among female sex workers in the Russian Federation. *International Journal of Drug Policy*. 2015.
13. Medhi GK, Mahanta J, Kermode M, Paranjape RS, Adhikary R, Phukan SK, et al. Factors associated with history of drug use among female sex workers (FSW) in a high HIV prevalence state of India. *BMC public health*. 2012;12(1):273.
14. Strathdee SA, Philbin MM, Semple SJ, Pu M, Orozovich P, Martinez G, et al. Correlates of injection drug use among female sex workers in two Mexico–US border cities. *Drug and alcohol dependence*. 2008;92(1):132-40.
15. Ross MW, Crisp BR, Månsson S-A, Hawkes S. Occupational health and safety among commercial sex workers. 2012.
16. Platt L, Jolley E, Rhodes T, Hope V, Latypov A, Reynolds L, et al. Factors mediating HIV risk among female sex workers in Europe: a systematic review and ecological analysis. *BMJ open*. 2013;3(7).
17. Prüss-Ustün A, Wolf J, Driscoll T, Degenhardt L, Neira M, Calleja JMG. HIV due to female sex work: regional and global estimates. *PloS one*. 2013;8(5):e63476.
18. El-Bassel N, Shaw SA, Dasgupta A, Strathdee SA. Drug use as a driver of HIV risks: re-emerging and emerging issues. *Current Opinion in HIV and AIDS*. 2014;9(2):150-5.
19. Croxford S, Platt L, Hope VD, Cullen KJ, Parry JV, Ncube F. Sex work amongst people who inject drugs in England, Wales and Northern Ireland: Findings from a National Survey of Health Harms and Behaviours. *International Journal of Drug Policy*. 2014.
20. Lau JT, Tsui HY, Zhang Y, Cheng F, Zhang L, Zhang J, et al. Comparing HIV-related syringe-sharing behaviors among female IDU engaging versus not engaging in commercial sex. *Drug and alcohol dependence*. 2008;97(1):54-63.
21. Decker MR, Crago A-L, Chu SK, Sherman SG, Seshu MS, Buthelezi K, et al. Human rights violations against sex workers: burden and effect on HIV. *The Lancet*. 2014.
22. Decker MR, Pearson E, Illangasekare SL, Clark E, Sherman SG. Violence against women in sex work and HIV risk implications differ qualitatively by perpetrator. *BMC public health*. 2013;13(1):876.
23. Ratinthorn A, Meleis A, Sindhu S. Trapped in circle of threats: violence against sex workers in Thailand. *Health care for women international*. 2009;30(3):249-69.
24. Shannon K, Strathdee SA, Shoveller J, Rusch M, Kerr T, Tyndall MW. Structural and environmental barriers to condom use negotiation with clients among female sex workers: implications for HIV-prevention strategies and policy. *American journal of public health*. 2009;99(4):659.
25. Shannon K, Csete J. Violence, condom negotiation, and HIV/STI risk among sex workers. *JAMA*. 2010;304(5):573-4.
26. Choudhury SM, Anglade D, Park K. From violence to sex work: agency, escaping violence, and HIV risk among establishment-based female sex workers in Tijuana, Mexico. *Journal of the Association of Nurses in AIDS Care*. 2013;24(4):368-82.
27. Erausquin JT, Reed E, Blankenship KM. Police-related experiences and HIV risk among female sex workers in Andhra Pradesh, India. *Journal of Infectious Diseases*. 2011;204(suppl 5):S1223-S8.

28. Decker MR, McCauley HL, Phuengsamran D, Janyam S, Silverman JG. Sex trafficking, sexual risk, sexually transmitted infection and reproductive health among female sex workers in Thailand. *Journal of epidemiology and community health*. 2010.
29. Decker MR, Wirtz AL, Baral SD, Peryshkina A, Mogilnyi V, Weber RA, et al. Injection drug use, sexual risk, violence and STI/HIV among Moscow female sex workers. *Sexually transmitted infections*. 2012;88(4):278-83.
30. Strathdee SA, Crago A-L, Butler J, Bekker L-G, Beyrer C. Dispelling myths about sex workers and HIV. *The Lancet*. 2015;385(9962):4-7.
31. Campbell JC. Health consequences of intimate partner violence. *The Lancet*. 2002;359(9314):1331-6.
32. Jewkes RK, Levin JB, Penn-Kekana LA. Gender inequalities, intimate partner violence and HIV preventive practices: findings of a South African cross-sectional study. *Social science & medicine*. 2003;56(1):125-34.
33. Panchanadeswaran S, Johnson SC, Sivaram S, Srikrishnan AK, Latkin C, Bentley ME, et al. Intimate partner violence is as important as client violence in increasing street-based female sex workers' vulnerability to HIV in India. *International Journal of Drug Policy*. 2008;19(2):106-12.
34. Zhang C, Li X, Hong Y, Chen Y, Liu W, Zhou Y. Partner violence and HIV risk among female sex workers in China. *AIDS and Behavior*. 2012;16(4):1020-30.
35. Mooney A, Kidanu A, Bradley HM, Kumoji EK, Kennedy CE, Kerrigan D. Work-related violence and inconsistent condom use with non-paying partners among female sex workers in Adama City, Ethiopia. *BMC public health*. 2013;13(1):771.
36. El-Bassel N, Gilbert L, Wu E, Go H, Hill J. Relationship between drug abuse and intimate partner violence: a longitudinal study among women receiving methadone. *American Journal of Public Health*. 2005;95(3):465-70.
37. Shannon K, Strathdee SA, Goldenberg SM, Duff P, Mwangi P, Rusakova M, et al. Global epidemiology of HIV among female sex workers: influence of structural determinants. *The Lancet*. 2015;385(9962):55-71.
38. Shannon K, Rusch M, Shoveller J, Alexson D, Gibson K, Tyndall MW. Mapping violence and policing as an environmental–structural barrier to health service and syringe availability among substance-using women in street-level sex work. *International Journal of Drug Policy*. 2008;19(2):140-7.
39. Kenya FIDA. Documenting human rights violations of sex workers in Kenya. Nairobi: Open Society Foundation, 2008.
40. Crago A. Arrest the violence: Human rights abuses against sex workers in Eastern Europe and Central Asia. Sex Workers' Rights Advocacy network (SWAn). 2009.
41. Ulibarri MD, Strathdee SA, Ulloa EC, Lozada R, Fraga MA, Magis-Rodríguez C, et al. Injection drug use as a mediator between client-perpetrated abuse and HIV status among female sex workers in two Mexico-US border cities. *AIDS and Behavior*. 2011;15(1):179-85.
42. Goldenberg SM, Rangel G, Vera A, Patterson TL, Abramovitz D, Silverman JG, et al. Exploring the impact of underage sex work among female sex workers in two Mexico–US border cities. *AIDS and Behavior*. 2012;16(4):969-81.
43. Silverman JG, Raj A, Cheng DM, Decker MR, Coleman S, Bridden C, et al. Sex trafficking and initiation-related violence, alcohol use, and HIV risk among HIV-infected female sex workers in Mumbai, India. *Journal of Infectious Diseases*. 2011;204(suppl 5):S1229-S34.
44. Campbell JC, Lucea MB, Stockman JK, Draughon JE. Forced sex and HIV risk in violent relationships. *American journal of reproductive immunology*. 2013;69(s1):41-4.
45. Stockman JK, Lucea MB, Campbell JC. Forced sexual initiation, sexual intimate partner violence and HIV risk in women: a global review of the literature. *AIDS and Behavior*. 2013;17(3):832-47.
46. Decker MR, Wirtz AL, Moguilnyi V, Peryshkina A, Ostrovskaya M, Nikita M, et al. Female sex workers in three cities in Russia: HIV prevalence, risk factors and experience with targeted HIV prevention. *AIDS and behavior*. 2014;18(3):562-72.
47. USAID. HIV/AIDS Health Profile: Europe and Eurasia Region. 2012.

48. UNAIDS. Report on the Global AIDS Epidemic. Geneva: 2012.
49. Clark F. Gaps remain in Russia's response to HIV/AIDS. *The Lancet*. 2016;388(10047):857.
50. Pokrovskiy V, Ladnaya N, Tushina O, Buravtsova E. HIV-Infection. Informational Bulletin #40 (ВИЧ-Инфекция. Информационный бюллетень №40). Moscow: Federal Scientific and Methodological Center for AIDS Prevention and Control (Федеральный научно-методический центр по профилактике и борьбе со СПИДом), 2015.
51. European Centre for Disease Prevention and Control, WHO Regional Office for Europe. HIV/AIDS surveillance in Europe 2015. Stockholm:: 2016.
52. UNAIDS. Country Progress Report of the Russian Federation on the Implementation of the Declaration of Commitment on HIV/AIDS. Moscow: 2008.
53. Cohen J. Praised russian prevention program faces loss of funds. *Science*. 2010;329(5988):168-.
54. Odinokova V, Rusakova M, Urada LA, Silverman JG, Raj A. Police sexual coercion and its association with risky sex work and substance use behaviors among female sex workers in St. Petersburg and Orenburg, Russia. *International Journal of Drug Policy*. 2014;25(1):96-104.
55. Smolskaya T, Yakovleva A, Kasumov V, Gheorgitsa S. HIV sentinel surveillance in high-risk groups in Azerbaijan, Republic of Moldova and in the Russian Federation. Europe: World Health Organisation (WHO). 2004.
56. United States Department of State. International Narcotics Control Strategy Report. 2014.
57. Heckathorn DD. Respondent-driven sampling: a new approach to the study of hidden populations. *Social problems*. 1997:174-99.
58. Straus MA, Hamby SL, Boney-McCoy S, Sugarman DB. The revised conflict tactics scales (CTS2) development and preliminary psychometric data. *Journal of family issues*. 1996;17(3):283-316.
59. World Health Organization UNPF, Joint United Nations Programme on HIV/AIDS, Global Network, of Sex Work Projects TWB. Implementing comprehensive HIV/STI programmes with sex workers: practical approaches from collaborative interventions. Geneva: World Health Organization, 2013.
60. Carlson CE, Chen J, Chang M, Batsukh A, Toivgoo A, Riedel M, et al. Reducing Intimate and Paying Partner Violence Against Women Who Exchange Sex in Mongolia Results From a Randomized Clinical Trial. *Journal of interpersonal violence*. 2012;27(10):1911-31.
61. Gupta J, Reed E, Kershaw T, Blankenship KM. History of sex trafficking, recent experiences of violence, and HIV vulnerability among female sex workers in coastal Andhra Pradesh, India. *International Journal of Gynecology & Obstetrics*. 2011;114(2):101-5.
62. Su S, Li X, Zhang L, Lin D, Zhang C, Zhou Y. Age group differences in HIV risk and mental health problems among female sex workers in Southwest China. *AIDS care*. 2014;26(8):1019-26.
63. Sarkar K, Bal B, Mukherjee R, Saha MK, Chakraborty S, Niyogi SK, et al. Young age is a risk factor for HIV among female sex workers—an experience from India. *Journal of Infection*. 2006;53(4):255-9.
64. Argento E, Muldoon KA, Duff P, Simo A, Deering KN, Shannon K. High prevalence and partner correlates of physical and sexual violence by intimate partners among street and off-street sex workers. *PloS one*. 2014;9(7):e102129.
65. El-Bassel N, Witte SS, Wada T, Gilbert L, Wallace J. Correlates of partner violence among female street-based sex workers: substance abuse, history of childhood abuse, and HIV risks. *AIDS patient care and STDs*. 2001;15(1):41-51.
66. Dandona R, Dandona L, Gutierrez JP, Kumar AG, McPherson S, Samuels F, et al. High risk of HIV in non-brothel based female sex workers in India. *BMC Public Health*. 2005;5(1):87.
67. Hong Y, Zhang C, Li X, Liu W, Zhou Y. Partner violence and psychosocial distress among female sex workers in China. *PloS one*. 2013;8(4):e62290.
68. Lang DL, Salazar LF, DiClemente RJ, Markosyan K. Gender based violence as a risk factor for HIV-associated risk behaviors among female sex workers in Armenia. *AIDS and Behavior*. 2013;17(2):551-8.

69. Karandikar S, Gezinski LB. Intimate partner violence and HIV risks among female sex workers of Mumbai, India. *Journal of Ethnic And Cultural Diversity in Social Work*. 2013;22(2):112-28.
70. Weine S, Golobof A, Bahromov M, Kashuba A, Kalandarov T, Jonbekov J, et al. Female migrant sex workers in Moscow: gender and power factors and HIV risk. *Women & health*. 2013;53(1):56-73.
71. Napper LE, Fisher DG, Reynolds GL, Johnson ME. HIV risk behavior self-report reliability at different recall periods. *AIDS and Behavior*. 2010;14(1):152-61.
72. UNAIDS. Global AIDS response progress reporting 2014: construction of core indicators for monitoring the 2011 UN political declaration on HIV/AIDS. 2014.
73. Murray L, Moreno L, Rosario S, Ellen J, Sweat M, Kerrigan D. The role of relationship intimacy in consistent condom use among female sex workers and their regular paying partners in the Dominican Republic. *AIDS and Behavior*. 2007;11(3):463-70.
74. Peitzmeier S, Mason K, Ceesay N, Diouf D, Drame F, Loum J, et al. A cross-sectional evaluation of the prevalence and associations of HIV among female sex workers in the Gambia. *International journal of STD & AIDS*. 2013;0956462413498858.
75. Schisterman EF, Cole SR, Platt RW. Overadjustment bias and unnecessary adjustment in epidemiologic studies. *Epidemiology (Cambridge, Mass)*. 2009;20(4):488.
76. Decker MR, McCauley HL, Phuengsamran D, Janyam S, Seage GR, Silverman JG. Violence victimisation, sexual risk and sexually transmitted infection symptoms among female sex workers in Thailand. *Sexually Transmitted Infections*. 2010;86(3):236-40.
77. Swain SN, Saggurti N, Battala M, Verma RK, Jain AK. Experience of violence and adverse reproductive health outcomes, HIV risks among mobile female sex workers in India. *BMC Public Health*. 2011;11(1):357.
78. Shannon K, Kerr T, Strathdee SA, Shoveller J, Montaner JS, Tyndall MW. Prevalence and structural correlates of gender based violence among a prospective cohort of female sex workers. *BMJ*. 2009;339.
79. Ditmore M. When sex work and drug use overlap. *Harm Reduction International*, 2013.
80. Bourgois P, Prince B, Moss A. The everyday violence of hepatitis C among young women who inject drugs in San Francisco. *Human organization*. 2004;63(3):253-64.
81. Abdala N, Hansen NB, Toussova OV, Krasnoselskikh TV, Verevchkin S, Kozlov AP, et al. Correlates of unprotected sexual intercourse among women who inject drugs or who have sexual partners who inject drugs in St Petersburg, Russia. *J Fam Plann Reprod Health Care*. 2013;39(3):179-85.
82. Lim S, Peitzmeier S, Cange C, Papworth E, LeBreton M, Tamoufe U, et al. Violence against female sex workers in Cameroon: accounts of violence, harm reduction, and potential solutions. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2015;68:S241-S7.
83. Beattie TS, Isac S, Bhattacharjee P, Javalkar P, Davey C, Raghavendra T, et al. Reducing violence and increasing condom use in the intimate partnerships of female sex workers: study protocol for Samvedana Plus, a cluster randomised controlled trial in Karnataka state, south India. *BMC public health*. 2016;16(1):660.
84. Beattie TS, Bhattacharjee P, Ramesh B, Gurnani V, Anthony J, Isac S, et al. Violence against female sex workers in Karnataka state, south India: impact on health, and reductions in violence following an intervention program. *BMC public health*. 2010;10(1):476.

5. Synergistic epidemics, or just co-occurring? Extending analytic frameworks for evaluating syndemics in a sample of Russian sex workers

Abstract

Background: Female sex workers (FSW) are disproportionately affected by the intertwined epidemics of substance use, violence, and HIV. They have 13.5 times higher odds of HIV infection as compared to other adult women, which is driven in large part by disproportionately high rates of experiencing violence and substance use. Syndemics, or synergistic epidemics, were first described by a medical anthropologist as intertwined health conditions that synergistically interact to produce excess burden of disease on the population. Operationalizing “synergy” and testing for it quantitatively remains contested. Typically, researchers have used a linear dose-response approach to show that as the number of syndemic conditions increases, so too does the risk of another health outcome of interest, arguing that this proves the “excess burden of disease” tenet of syndemics theory. Building on recent methodological proposals in the literature, we question whether this truly demonstrates synergism, and propose and implement three approaches to test for synergism.

Methods: Using a FSW-specific, violence-focused syndemic model based on the substance abuse, violence, and AIDS (SAVA) syndemic, we first conduct traditional linear dose-response analyses to test whether risk of three HIV risk outcomes – injecting drug use, inconsistent condom use with clients, and inconsistent condom use with intimate partners – rises with the number of types of violence experienced by FSW (client, police, intimate partner, and pimp violence). We then outline and apply three approaches to test for synergism: 1) adding a quadratic term to dose-response models and testing for significance of a supra-linear trend, 2) for each pairwise combination of violence types, testing for interaction effects on the multiplicative scale, and 3) for each pairwise combination of violence types, testing for interaction

effects on the additive scale. Data are from a sample of 754 female sex workers from Kazan, Tomsk, and Krasnoyarsk, Russia.

Results: Linear dose-response analyses showed a statistically significant association between the number of types of violence experienced and injecting drug use (ARR 1.37, 95% CI 1.04, 1.81), inconsistent condom use with clients (ARR 1.27, 95% CI 1.07, 1.49), and inconsistent condom use with intimate partners (ARR 1.04, 95% CI 1.01, 1.08). Quadratic dose-response, multiplicative interaction, and additive interaction analyses had null findings for all outcomes and violence types.

Conclusions: Significant findings from the linear dose-response method demonstrate substantially heightened HIV risk as violence types accumulate. This finding would traditionally be interpreted as evidence of synergy in standard syndemic analyses. All three methods proposed to measure the synergism element of syndemics failed to provide quantitative evidence of a synergistic effect of violence types, i.e., excess sexual and drug-related HIV risk via interaction between syndemic factors. This case example offers a concrete illustration of recent methodological critiques that “syndemics” that meet standard linear dose-response tests may not be synergistic. The theoretical language and the quantitative analyses used in this field should be better aligned by extending standard analytic frameworks as described in this chapter.

Introduction

Syndemic theory describes “synergistic epidemics,” i.e. multiple health issues that co-occur and 1) are mutually reinforcing and enhancing, 2) synergistically interact to produce excess burden of disease on the population, 3) influenced by structural violence and social inequality, and 4) so intertwined that they cannot be addressed in isolation.[1, 2] Syndemic theory argues that syndemic factors, while individual and distinct, form a holistic conglomeration of diseases and cannot be fully extricated from one another.[3] There is a strong focus on the social determinants of health, often arguing that syndemic factors would not necessarily be mutually reinforcing but for poverty, unequal access to health care, or other injustices that create the conditions that give rise to these disease conglomerations.[4]

Since medical anthropologist Merrill Singer first introduced the concept of syndemics in 1996 using the example of the substance abuse, violence, and AIDS (SAVA) syndemic,[1] it has been applied to a multitude of proposed syndemics, including asthma and influenza, hepatitis and HIV, and tuberculosis and HIV.[5] The syndemics literature has grown at an increasing pace in recent years, especially quantitative empirical work that seeks to build on the first wave of qualitative and theoretical work on syndemics. A recent systematic review found 71 such quantitative articles[6] in a Lancet series focused on syndemics[4] in March 2017. In particular, there is a fairly extensive literature applying a syndemic framework to men who have sex with men (MSM), but just 14% of articles investigated syndemics in samples of women.[6]

FSW-specific syndemic framework

The application of SAVA to cisgender women’s HIV risk and female sex workers (FSW) in particular lags behind: In a recent review of quantitative evidence for the SAVA syndemic among US women, only one of 45 articles focused specifically on FSW.[7] FSW are a particularly salient population for the SAVA syndemic given high burdens of substance use, violence, and HIV in this population. A systematic review of studies from 50 countries found that FSW have an average HIV prevalence of 11.8%

and have 13.5 times higher odds of HIV infection than the overall population of adult women.[8] FSW also shoulder a high burden of substance use[9] and physical and sexual violence victimization.[10] As in the general population,[7, 11, 12] increasing evidence links violence against FSW with substance abuse,[13-16] sexual risk behavior,[17] and HIV infection.[15, 18-20] Qualitative work among FSW has shown that sex work serves as “a mediating factor in the SAVA syndemic,” amplifying women’s risks for violence, HIV, and substance use through complex pathways.[2] Few analyses have built on this qualitative evidence by investigating the SAVA syndemic in sex work context from a quantitative standpoint.

Theoretically, the original SAVA model is broadly applicable to many populations of women,[7] but this broadness means it does not make explicit important particularities of FSWs’ violence and HIV risk environment. Importantly, while researchers have explored multiple types of violence under the SAVA umbrella, the original SAVA theory conceptualizes violence as a single component rather than explicitly differentiating violence from different perpetrators as individual factors within the SAVA syndemic (Fig 1). While women globally are predominantly at risk of intimate partner violence (IPV), female sex workers (FSW) are additionally vulnerable to violence from clients, police, and pimps due to their occupation, and each type of violence has different implications for HIV and substance use.[21] We propose a violence-focused, sex work-specific syndemic model that explicitly extends the original SAVA framework (Figure 1). Our model incorporates polyvictimization and distinguishes the four most common types of violence – violence from clients, intimate partners, police, and pimps –as separate, yet intertwined, syndemic factors (Figure 2). In our theoretical framework, the multiple types of violence FSW are exposed to are the syndemic factors, and the health outcomes of interest are sexual and drug-related HIV risk. According to a recent systematic review, this is the first quantitative application of the syndemics framework to look at more than two types of violence,[6, 22] developing our understanding of whether different types of violence may function as a syndemic in polyvictimized populations. It is also the first study to exclusively use specific forms of violence as the syndemic factors rather than also including some HIV risk behaviors as syndemic factors. In our analysis, we reserve sexual and drug-

related HIV risk behaviors as the outcomes in the analyses. There is no one standard, accepted set of syndemic factors or outcomes to examine in the SAVA literature.[6, 22]

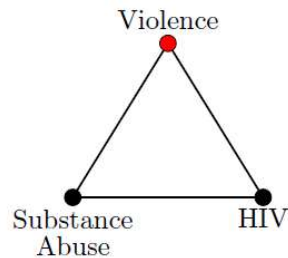


Figure 5.2: Original SAVA syndemic model proposed by Singer et al.

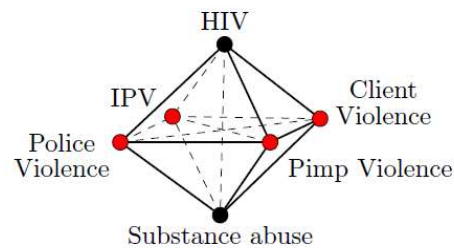


Figure 5.2: Extended syndemic model incorporating polyvictimization, as proposed in this work. We look separately at substance abuse-related HIV risk and sexual HIV risk in the analyses.

In Chapter 1, we demonstrated that all forms of violence are associated with one another. This is in line with standard syndemic analysis showing that syndemic factors are “mutually reinforcing.” We now turn our attention to the second key concept of syndemic theory, that syndemic factors “synergistically interact to produce excess burden of disease on the population.”

Current analytic standards for demonstrating synergy in syndemics research

Syndemic research is complicated by linguistic confusion over what is meant quantitatively by qualitative language referring to “synergistic” or “interacting” epidemics.[23, 24] Syndemic theory arose from a qualitative anthropology discipline. The quantitative tools to operationalize that language and measure the concepts it describes have not been solidified. Singer refers to “biological interactions” and “synergistic interaction,” but there is no clear agreement in the field about whether conceptual language around “interacting” and “synergistic” epidemics should translate into statistically significant multiplicative interaction terms in regression models, or if two distinct concepts are being conflated due to similar terminology. While many scholars have retained the original language of “synergistic” and

“interacting” factors,[25] others studiously avoid those words, which can connote multiplicative interaction effects, in favor of words like “additive interplay.”[26] Others even avoid suggesting that “syndemic factors interrelate and amplify” risk,[27] and instead simply state that “an increasing number of co-occurring syndemic factors [is] associated with a proportional increase” in risk.[28] This last example, in contrast to others, suggests there is no synergism or interaction effect on any scale: The whole is no more than the sum of the independent parts.

Regardless of the language used to frame the analyses, syndemic analyses (as well as analyses in the polyvictimization literature) tend to follow a standard pattern. After demonstrating that syndemic factors are “mutually reinforcing”, most researchers demonstrate “synergism” using a linear dose-response analysis, also known as an “additive model” or “sum score of exposures.” The linear dose-response analysis determines if the risk of health outcomes of interest increases as the number of syndemic factors experienced increases.[26, 27, 29-31] This approach seems to have become the relatively unquestioned standard because one of the first seminal quantitative syndemics articles, by Stall et al in 2003, used it.[22] This approach may have been borrowed from polyvictimization analyses, which arose in the field of child abuse research. The ground-breaking Adverse Childhood Experiences (ACE) study used a dose-response framework to show that as the number of ACEs accumulated, the risk of myriad health problems in adulthood dramatically increased.[29] Articles using this approach interpret a significant linear trend as proving evidence of a synergistic epidemic, and explicitly or implicitly suggest that this analytic approach operationalizes the concept of “synergistically” “interacting” to produce “excess” burden of disease in the population.[22]

However, the linear dose-response or additive model does not adequately operationalize synergy in an epidemiological or statistical sense. It does not test for *excess* risk beyond the independent effects of each individual syndemic factor and cannot identify pairs of co-occurring exposures that exhibit a synergistic effect (beyond a proportionally additive effect) on health. The linear dose-response test only shows that there is more burden to health as the number of exposures rises. Unfortunately, this test is

uninformative because if each syndemic factor is associated with HIV risk on its own, then it is tautological that having two of these factors will be worse than having just one, and that three would be worse than two. Indeed, Tsai and Venkataramani offer a simple mathematical proof demonstrating that as long as each individual factor is associated with the outcome, there will also necessarily be a linear dose-response pattern.[32] As Tsai et al state in their recent review[6], “Although helpful, in some instances, for understanding the health effects of cumulative adversities, the [linear dose-response test] sheds light on the co-dynamics of neither interaction nor mutual causality.” Approximately 35% of quantitative syndemic articles using this approach explicitly and incorrectly assert that this analytic approach operationalizes the concept of “synergistically” “interacting” to produce excess burden of disease in the population.[22]

The dose-response approach is also limited because a sum score of exposures implicitly treats all syndemic factors as interchangeable. A count variable with a linear test for trend implicitly models each exposure as having a unit effect on the outcome, even though some exposures might have a larger effect than others. It also cannot identify the most important exposures or combinations of exposures to address using interventions. Taken to an extreme in the polyvictimization literature, dose-response analyses of adverse childhood experiences have implicitly treated adverse experiences as different as having parents divorce and being sexually abused as interchangeable in expected impact on health, when they are demonstrably not.[33] This lack of specificity has obscured important differences between factors within a given syndemic, diluting the ability to target interventions toward particularly potent syndemic exposures or co-occurring pairs of exposures that interact synergistically to produce excess risk.

Only a handful of quantitative syndemics articles have investigated synergistic interaction.[6] In her thesis work, Illangasekere looked at multiplicative interaction effects between syndemic factors, none of which were significant; interaction analyses were dropped when the manuscript was published as a journal article.[34, 35] Herrick also used interaction analyses in her dissertation and is the only researcher identified in a recent systematic review[6] to have examined both multiplicative and additive interaction.[36] While hers was one of only 6 studies ever to find significant multiplicative interaction

effects,[6, 22] she did not compute confidence intervals or p-values for her measures of additive interaction because she acknowledges her sample is too small to adequately power the analysis, leaving the reader unable to judge whether additive interaction is taking place.

The synergism concept from syndemic theory can be better evaluated using new analytic approaches that extend common linear dose-response approaches. In this work, we build on recent methodological proposals[6] and propose a comprehensive approach to quantitatively measuring synergy, using a FSW-specific SAVA syndemic model as a case example. This approach avoids previously mentioned limitations of traditional syndemic and polyvictimization analyses, as it allows for uneven exposure effects, the identification of the most important exposures and exposure patterns, and the identification of synergistic effects between specific exposures.

Methods

Study Setting

Russia is one of just a few countries in the world where HIV prevalence and incidence are still increasing.[37-40] Russia has the highest incidence in Europe; incident infections have risen on average almost 11% per year in the last decade, rising from 39,402 infections in 2005 to 98,177 in 2015.[41] Russia is transitioning toward a heterosexual contact-driven HIV epidemic from an injecting drug use-driven epidemic, particularly among women. In 2008, 63% of incident infections among women were due to sexual contact,[42] a number that may be increasing through time: Only 18.7% of prevalent infections among women in 2015 were due to injecting drug use.[40] Since 2012, foreign and multilateral donors have left or been ejected from the country, and the Russian government has not funded FSW-focused programs.[43] IDU is common among Russian FSW, with estimates including 17.7% lifetime use in Moscow[16] and 47.5% past-day use in St. Petersburg and Orenburg.[14] Recent research demonstrates prevalent physical and sexual violence against FSW.[14, 16, 19] Sex work is criminalized in Russia and

punishable by a fine of 2000 rubles (\$60) while drug use is punishable with punitive detoxification programs, fines, or imprisonment.[44]

Kazan is the eighth largest city in Russia and is 500 miles east of Moscow. Tomsk and Krasnoyarsk are located in Siberia. Tomsk (population 524,669) is the smallest, least industrial site and boasts several universities. Krasnoyarsk (population 1,035,528) is an industrial center located along the Trans-Siberian railway; historically Krasnoyarsk was the site of a gulag forced labor camp. All cities have significant sex work industries. Women typically work on the street, in saunas, hotels, online, or from *tochkas* (areas along streets where sex workers gather and meet clients out of cars). The number of sex workers in Russia is thought to be steadily on the rise due to economic pressures, including globalization, increasing unemployment, migration from rural to urban areas in search of work, and continuing ripples felt from the massive economic transition after the fall of the Soviet Union and from the recent financial crisis.[45]

Data collection

Data were collected in 2011 from a sample of n=754 FSW from Tomsk, Kazan, and Krasnoyarsk, Russia as part of a large-scale program evaluation for Global Fund program activities, Global Efforts Against HIV/AIDS in Russia (GLOBUS).[19] The primary objective was to evaluate GLOBUS by assessing program coverage, HIV knowledge, risk behaviors, condom use, and HIV prevalence among FSW. The survey collected detailed data on sex work context, including exposure to violence.

Study recruitment and eligibility

Recruitment was via respondent-driven sampling (RDS)[46] at each site with respondents given 5 recruitment coupons each. RDS was chosen due to the difficulty of creating a sampling frame and using random sampling in a hard-to-reach population.[46] Individuals were eligible for the study if they were

non-transgender women, at least 18 years old, worked or resided in one of the three cities, and had exchanged sex for money, drugs, or shelter in the past 3 months. Seeds were purposively selected by local partners to maximize diversity, including street and off-street sex work and injecting and non-injecting FSW. Study interviewers were local Russian non-governmental organization (NGO) staff trained by Johns Hopkins University staff. Interviews in Tomsk and Krasnoyarsk took place in the local NGO's office; in Kazan interviews were also conducted in a mobile unit at locations across the city due to the remoteness of the local office. Verbal informed consent was used to protect confidentiality. Interviews were self-administered on a computer and took 20-30 minutes, followed by OraQuick HIV testing. Women received a small gift (<\$5USD) for participation. The study was approved by Open Health Institute in Moscow, Russia and considered exempt as public health practice by the Johns Hopkins School of Public Health Institutional Review Board. The current secondary analysis of existing, de-linked, deidentified data was considered not human subjects research by the same IRB. Further details are published elsewhere.[19]

Exposure measures/Syndemic factors: violence from intimate partners, clients, pimps and police.

Extensive qualitative formative research using in-depth interviews and focus groups with FSW and service providers informed survey development and implementation.[19] The violence exposures are lifetime exposure to intimate partner violence (physical), client violence (physical or sexual), pimp/momka violence (physical or sexual), and police violence (sexual) (See Table 2). Extensive formative research identified these types of violence as the most relevant forms of physical or sexual violence in the lives of FSW in this setting. Measures are based on the Conflicts Tactics Scale 2 (CTS-2) which asks about specific behaviors rather than asking about abuse generally,[47] the standard in the field.[48] The CTS-2 has been validated in diverse samples and adapted to sex work populations.[49, 50] Formative research also informed development of more setting-specific behaviors, such as common types of physical abuse from pimps or momkas, asking about anal and vaginal rape separately in the client

violence measures, and asking about *subbotnik*, or coerced sex with police officers in order to avoid arrest.[19]

Table 5.1: Survey items measuring violence victimization exposures of interest.

Source	Measure
Intimate partner	Think about your boyfriends, husband, or other people you have dated. Have you been hit, pushed, slapped, or otherwise physically hurt by a boyfriend, husband, or someone you were dating?
Client	Have you been hit, pushed, slapped, or otherwise physically hurt by a client?
	Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a client?
	Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>vaginal</i> sex when you didn't want to?
	Have you had a client use force (like hitting, holding you down, or using a weapon) to make you have <i>anal</i> sex when you didn't want to?
Pimp/momka	Have you been hit, pushed, slapped, or otherwise physically hurt by a pimp/momka?
	Have you been beaten, strangled, choked, stabbed, threatened with a weapon, or thrown out of a moving car by a pimp/momka?
	Has your pimp ever forced you to have sex when you did not want to?
Police	How many times have you been involved in a subbotnik (asked to provide sex to police or militia to avoid incarceration or arrest)?
	In the past 6 months, have you had to pay or compensate the police for the ability to sell sex or stand on the street? Options include: Yes, had to provide sex

There were two additional client violence measures available in the survey specific to pressured or coerced vaginal or anal sex, “Have you had a client pressure you for or insist on *vaginal* sex when you did not want to (but did not use physical force)” and “Have you had a client pressure you for or insist on *anal* sex when you did not want to (but did not use physical force).” Because there were not similar measures on pressured or coerced sex for any other type of perpetrator, these two items were not used in the main analysis. The 4-item assessment was used in the main analysis to enhance comparability across perpetrators. A sensitivity analysis was undertaken comparing the results of the 4-item assessment with the available 6-item assessment for client violence. Results using the 6-item definition of client violence

(inclusive of sexual coercion) were qualitatively similar to results using the 4-item definition restricted to forced sex. We therefore proceed below with the 4-item measure.

The following variables are included in adjusted models as potential confounders based on a review of the literature and bivariate association with at least one of the four violence exposures at $p < 0.1$: age,[51, 52] engaging in street-based sex work (binary),[14, 17, 53-55] average number of vaginal or anal sex clients per night,[16] having another income besides sex work,[53, 56] current number of non-paying intimate partners,[57] duration of time in sex work,[56] education level,[58] age of entry into sex work,[59, 60] relationship status (categorical),[56, 61] and monthly salary.[62]

Outcome variables

The drug-related HIV risk outcome is injecting drugs in the past 6 months. Respondents were asked “Have you ever used a needle to inject drugs?” and given the options of “Yes, in the past 6 months,” “Yes, not in the past 6 months, but before that,” and “No.” Given the high levels of injecting drug use among FSW in the Russian context,[14] this is a key source of HIV risk. Drug use was chosen as an outcome rather than needle sharing specifically as it is simpler to assess, is likely less prone to recall or social desirability biases, was more prevalent and so provided greater power for statistical analyses, and is still a valid marker of drug-related HIV risk.

The sexual HIV risk outcomes are 1) inconsistent condom use with clients in the past 6 months and 2) inconsistent condom use with current main non-paying sex partner (i.e. intimate partner). Respondents were asked “Over the past 6 months, how often did you use a condom with clients during vaginal sex?” and “Over the past 6 months, how often did you use a condom with clients during anal sex?” and given response options of always, often, half the time, sometimes, rarely, and never. Participants who responded “always” to both questions were considered consistent condom users with clients; otherwise they were considered to have the outcome of inconsistent condom use with clients. To

assess inconsistent condom use with an intimate partner, participants were asked to think of their current, main, nonpaying sexual partner and asked “How often do you use condoms with this partner?”

Participants who stated that they “always” use condoms were considered consistent condom users with their intimate partner; otherwise they were considered to have the outcome of inconsistent condom use with their intimate partner. Assessing condom usage with clients is one of the UNAIDS core indicators.[63] Unprotected sex with intimate partners is an important HIV risk source given higher frequency of unprotected sex with intimate partners as compared to clients[64, 65] and the association between having an intimate partner and HIV risk for FSW in many settings.[57, 66, 67]

Regression models with the outcome of inconsistent condom use with intimate partners only used FSW who reported having a current intimate partner (N=431) rather than the full sample (N=754), as only this subset was at risk for the outcome.

Missing data

Multiple imputation with chained equations was used to impute missing data. The amount of missing data for each variable used in the analysis ranged from 0.3% to 10.4%; intimate partner violence was the only variable missing more than 10% of values. Approximately 16% of the sample was missing at least one of the four key violence exposure variables (0.4% for pimp violence, 2.1% for police violence, 7.6% for client violence, and 10.4% for intimate partner violence). Key exposure variables, variables indicating cluster membership, potential demographic confounders, and all variables found to be associated with key exposure variables or associated with missingness in those variables, were identified for inclusion in the imputation model. Because of difficulties with model convergence due to the number of variables, variables that were missing less than 2% of values were imputed using the mean or mode of respondents in the same recruitment chain. The remaining variables were imputed via multiple imputation with 20 multiply imputed datasets.

Standard linear dose-response analysis

We first use a standard linear dose-response analysis, exploring the hypothesis that as the number of syndemic factors (i.e. types of violence) increases, the effect on health outcomes (injecting drug use, inconsistent condom use with clients, and inconsistent condom use with intimate partners) increases. Each participant was assigned a syndemic factors count variable ranging between 0 and 4 corresponding to the number of types of violence they experienced. The prevalence of the health outcome was calculated for each of the syndemic count tiers (0, 1, 2, 3, or 4 exposures). Using those who experienced no violence as the reference category, the risk ratio for the outcome was calculated for those who experienced 1, 2, 3, and 4 types of violence. This descriptive information is often provided in standard syndemic analyses. To formally test for the significance of a linear dose-response effect, we build a regression model where the syndemic count variable is modeled as continuous rather than categorical.

Synergism analyses

We propose three analyses that test for synergism using a variety of approaches and scales.

Table 5.2: Summary of analytic methods

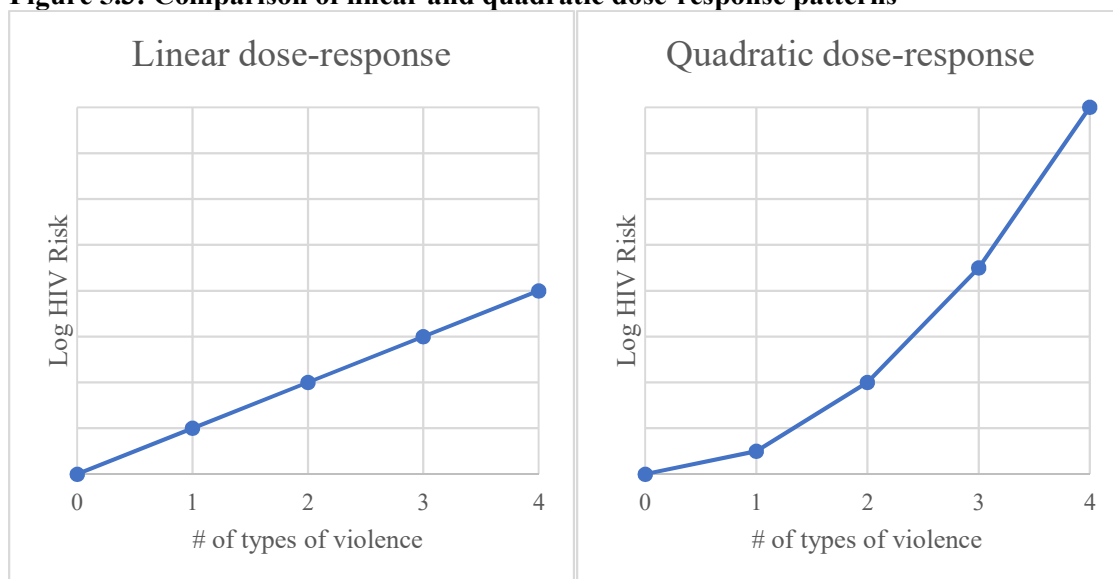
	Number of terms required per model	Tests for synergism ?	Allows factors to be distinct?	Other pros and cons
Analyses conducted				
<i>Standard approach in the literature:</i>				
Linear dose-response $\text{Log}(Y_i) = \beta_0 + \beta_1 x$ Where x is a sum score of exposures	1	NO	NO	Simple
<i>Novel approaches applied in the dissertation:</i>				
Quadratic dose-response $\text{Log}(Y_i) = \beta_0 + \beta_1 x_i^2 + \beta_2 x_i$ Where x is a sum score of exposures	2	YES	NO	Simple
Pairwise multiplicative interaction $\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{1i} x_{2i}$ Where x_1 and x_2 are specific syndemic exposures	3	YES	YES	Requires many models

Pairwise additive interaction $\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{1i} x_{2i}$ $\text{RERI} = (e^{\beta_1 + \beta_2 + \beta_3} - 1) - (e^{\beta_1} - 1) - (e^{\beta_2} - 1)$ Where x_1 and x_2 are specific syndemic exposures	3	YES	YES	Requires many models
Other proposals from the literature:				
Fully saturated interaction analysis[32] $\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + \beta_5 x_{1i} x_{2i} + \beta_6 x_{1i} x_{3i} + \beta_7 x_{1i} x_{4i} + \beta_8 x_{2i} x_{3i} + \beta_9 x_{2i} x_{4i} + \beta_{10} x_{3i} x_{4i} + \beta_{11} x_{1i} x_{2i} x_{3i} + \beta_{12} x_{1i} x_{2i} x_{4i} + \beta_{13} x_{1i} x_{3i} x_{4i} + \beta_{14} x_{2i} x_{3i} x_{4i} + \beta_{15} x_{1i} x_{2i} x_{3i} x_{4i}$ Where x_1 to x_4 are specific syndemic exposures	$2^n - 1$ for n factors	YES	YES	Theoretically ideal, but requires large sample and exponential number of terms

Synergism analysis 1: Quadratic dose-response

The quadratic model is able to capture cases where the relationship between the “dose” of violence (i.e. number of types of violence) experienced and the “response” in the risk of the outcome is curved (Figure 3). Whereas the standard linear dose-response analysis assumes a constant rate of change as participants experience additional forms of violence, the quadratic model indicates synergism by showing accumulation of *excess* risk at higher “doses” of violence above and beyond the risk associated with each individual form of violence happening in isolation.

Figure 5.3: Comparison of linear and quadratic dose-response patterns



We model each HIV risk outcome in multivariate log-binomial regression models including the syndemic count variable, a squared syndemic count variable, and potential confounders. The significance of the quadratic regression coefficient indicates a significant quadratic dose-response.[68] Significance of a quadratic term would indicate a supra-additive relationship between syndemic count and the outcome in the case of a positive quadratic coefficient (risk ratio >1), or a plateau effect at high levels of syndemic count in the case of a negative quadratic coefficient (risk ratio <1). This would indicate positive or negative synergy, respectively.

Three log-binomial regression models, one for each outcome, take the form:

$$\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i}^2 + \beta_2 x_{1i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni}$$

Where Y is the probability of the HIV risk outcome of interest, w_1 through w_n represent potential confounders included in the model, and x_1 is a count variable taking the values 0, 1, 2, 3, or 4 corresponding to the number of types of violence experienced. This model has a quadratic term ($\beta_1 x_{1i}^2$) and a linear term ($\beta_2 x_{1i}$), whereas the linear dose-response above only has a linear term. Significance of the coefficient β_1 indicates synergy.

Mathematically, the quadratic test-for-trend approach is identical to testing for multiplicative interaction, with the simplifying assumptions that 1) all types of violence have the same main effect, 2) all pairwise combinations of violence have the same interaction effect, and 3) there are no higher-order interactions.

To see this, let A, B, C, and D be binary indicator variables for the four forms of violence. Then x_1 , the count variable for number of violence exposures, can be defined as $x_1 = A + B + C + D$. Further, because A, B, C, and D only take value 0 or 1, then $A^2 = A$, $B^2 = B$, $C^2 = C$, and $D^2 = D$. Using these facts, we can re-express the quadratic and linear terms in our model, $\beta_1 x_{1i}^2 + \beta_2 x_{1i}$, in terms of the violence exposure variables A, B, C, and D:

$$\begin{aligned}
\beta_1 x_{1i}^2 + \beta_2 x_{1i} &= \beta_1 (A+B+C+D)^2 + \beta_2 (A+B+C+D) \\
&= \beta_1 (A^2+B^2+C^2+D^2+2AB+2AC+2AD+2BC+2BD+2CD) + \beta_2 (A+B+C+D) \\
&= \beta_1 (A+B+C+D+2AB+2AC+2AD+2BC+2BD+2CD) + \beta_2 (A+B+C+D) \\
&= (\beta_1 + \beta_2)(A+B+C+D) + 2\beta_1 (AB+AC+AD+BC+BD+CD)
\end{aligned}$$

From the final equation, we can read that the quadratic test for trend model with coefficient β_1 on the quadratic term and coefficient β_2 on the linear term is equivalent to a fully saturated interaction model with coefficient $(\beta_1 + \beta_2)$ on each main effect, coefficient $2\beta_1$ on each pairwise interaction effect, and a 0 coefficient for all higher-order interactions.

Therefore, the quadratic dose-response test improves upon the linear dose-response test by testing mathematically for synergistic interaction. It still retains the issue that all syndemic factors are treated as interchangeable by use of a sum score of exposures (Table 3). The lack of specificity decreases interpretability for designing public health interventions that target specific combinations of factors. We propose this test, despite this limitation, because it is the simplest test possible that will actually mathematically test for synergy between syndemic factors. Previous authors have critiqued the multiplicative and additive interaction analyses proposed below for their sample size demands.[32] Statistically significant pairwise multiplicative interaction terms require a large sample size to achieve. The sample size required may be inflated further if syndemic factors are highly collinear (as would be predicted by their mutually causal nature), making pairwise multiplicative and additive interaction analyses a difficult and potentially unfairly high bar to clear to demonstrate synergism and resulting in Type II error.[22, 32] The quadratic dose-response test reduces the demands on sample size by use of strong simplifying assumptions that all syndemic factors have the same main effect and all pairwise combinations of factors have the same interaction effect. This makes the quadratic dose-response test a simple and feasible option to mathematically test for synergism in small to moderately sized samples.

Synergism analysis 2: Multiplicative interaction

Multiplicative interaction occurs if factor A is associated with an X times increase in risk of the outcome, factor B is associated with a Y times increase in risk of the outcome, and individuals who experience both factor A and factor B exhibit significantly greater than a X*Y times increase in risk of the outcome as compared to individuals who experience neither factor A nor factor B.[69] In log-binomial or Poisson regression models, this can be ascertained using a product term between factor A and factor B. Because there are three outcomes (injecting drug use, inconsistent condom use with intimate partner, and inconsistent condom use with clients) and six possible pairwise combinations of the four types of violence, we run 6 models for each of the 3 outcomes to understand the extent of multiplicative interaction between different types of violence in driving HIV risk outcomes. We include in each model 1) two binary exposure variables for two types of violence, 2) a multiplicative interaction term between those two types of violence, and 3) demographic confounders. A significant interaction coefficient indicates a significant interaction effect on the multiplicative scale.

For each of the three outcomes, six log-binomial regression models (one for each pairwise combination of violence exposures) test for interaction:

$$\begin{aligned}
 \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3^* x_{1i}^* x_{2i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\
 \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{1i} + \beta_2 x_{3i} + \beta_3^* x_{1i}^* x_{3i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\
 \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{1i} + \beta_2 x_{4i} + \beta_3^* x_{1i}^* x_{4i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\
 \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{2i} + \beta_2 x_{3i} + \beta_3^* x_{2i}^* x_{3i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\
 \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{2i} + \beta_2 x_{4i} + \beta_3^* x_{2i}^* x_{4i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni} \\
 \text{Log}(Y_i) &= \beta_0 + \beta_1 x_{3i} + \beta_2 x_{4i} + \beta_3^* x_{3i}^* x_{4i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni}
 \end{aligned}$$

Where Y represents the probability of the HIV risk outcome, x_1 through x_4 represent different types of violence exposures, and w_1 through w_n represent potential confounders included in the model. A significant interaction coefficient, β_5 through β_{10} , indicates a significant interaction effect on the multiplicative scale. Poisson regression was used where log-binomial models did not converge.

Unlike the dose-response approach, this approach allows us to look at an interaction effect between two specific types of violence while adjusting for exposure to confounders. Significance of the interaction term will indicate a multiplicative synergistic effect of experiencing both types of violence on

our outcomes, above and beyond the independent effect of each type of violence. This analysis also allows identification of specific pairings of violence that produce this synergistic effect.

In each model, we examine only two syndemic factors at a time and their interaction, rather than building a fully saturated model that includes all four syndemic factors and their interactions, including higher-order interactions. Our approach differs from that suggested by Tsai and Venkataramani, who recommend building a single, fully saturated model that includes all pairwise interaction terms and higher-order interaction terms.[32] Their approach results in an exponentially increasing number of terms ($2^n - 1$ for n syndemic factors) and in our case would have resulted in a model with 4 syndemic factor terms, 6 first-order interactions, 4 second-order interactions, and 1 third-order interaction, in addition to 10 potential confounders included as covariates. Even with a sample size of 754, this dataset would be underpowered for such a model given small cell sizes for some violence combinations (see Chapter 1). A single, fully saturated model is unrealistic for most datasets, albeit theoretically ideal, if examining 4 or more syndemic factors due to the exponentially increasing number of terms. Though Tsai and Burns estimate that about half of the papers in the syndemic literature should be able to support fully saturated models based on an approximate rule that 5-10 events are required per model covariate,[22] this estimate fails to take into account that syndemics are predicated on the idea that the syndemic factors are highly correlated, which drastically reduces power for interaction analyses. Further, interaction terms, being the product of two other terms in the model, are by definition highly collinear. To further address concerns about being underpowered in this analysis, we will also draw attention in the results to marginally significant findings in the interaction models at $p < 0.10$.

We do not adjust for other types of violence besides the two main violence exposures in each model. For instance, the model testing multiplicative interaction between police and client violence does not also adjust for pimp violence or IPV. Adjusting for a third type of violence may underestimate the total effect of the main types of violence on the outcome if the third type of violence is a mediator on the causal pathway between the main types of violence and the outcome (see Aim 2 for a fuller discussion).

Statistically, this approach also conserves power. However, this approach may not fully control for confounding between all types of violence.

Synergism analysis 3: Additive interaction

Additive interaction occurs if factor A is associated with X percentage points of increase in risk of the outcome, factor B is associated with Y percentage points of increase in risk of the outcome, and individuals who experience both factor A and factor B exhibit significantly greater than X+Y percentage points of increase in risk of the outcome than individuals who experience neither factor A nor factor B.[69] In log-binomial and Poisson regression models, this cannot be estimated directly in the model due to its multiplicative nature, but can be derived using model coefficients using the same models built for assessing multiplicative interaction (more details below). Some researchers assert that an additive, rather than a multiplicative, interaction effect may be of more interest from a public health standpoint because looking at an absolute increase in risk of the outcome directly estimates increased case load and health burden in a way a multiplicative model does not.[23, 68, 70, 71] Additive interaction therefore may “take precedence” over multiplicative interaction in identifying high-risk groups to target for interventions.[68] Solely examining multiplicative interaction effects may fail to identify additive interaction due to issues of *scale dependence*, as there may be interaction on the additive scale, but not the multiplicative scale, or vice versa. It is even possible to have a positive interaction on the additive scale but a negative interaction on the multiplicative scale simultaneously.[68] Given that little is known about how specific forms of violence interact in a syndemic context, it is unclear whether a multiplicative or additive interaction effect is most appropriate. To our knowledge, only one other quantitative empirical work has looked at multiplicative and additive interaction before in a syndemic context, examining alcohol misuse, drug use, and depression as three syndemic factors and any unprotected anal intercourse, unprotected insertive anal intercourse, and unprotected receptive anal intercourse as outcomes in a sample of men who have sex with men.[36] The author did not compute the significance of the additive interaction measures.

Presenting both additive and multiplicative interaction analyses is also consistent with best practices for presenting interaction effects.[71] Knol and VanderWeele suggest presenting the following information for optimal transparency in interaction analyses of exposures A and B: 1) ARR for the effect of exposure A on the outcome and the effect of exposure B on the outcome, 2) ARR of the effect of exposure A on the outcome within the stratum of patients experiencing exposure B and ARR of the effect of exposure B on the outcome within the stratum of patients experiencing exposure A, 3) both additive and multiplicative measures of interaction, and 4) the confounders adjusted for in regression models. Item 1 is presented in Chapter 2, while items 2 and 3 are presented in the present analysis.

When using a log-binomial regression model, additive interaction effects must be estimated using techniques such as the relative excess risk due to interaction (RERI), attributable proportion due to interaction (AP), or synergy index (SI).[70] The synergy index is preferred over the RERI and the AP in the multivariate setting because it provides a unique measure of interaction in the presence of covariates, [70] but it should also only be used if the doubly unexposed group has the lowest absolute risk of the outcome.[71] Because this was not true for all violence and outcome combinations, we present the RERI.

For a given model

$$\text{Log}(Y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 * x_{1i} * x_{2i} + \gamma_1 w_{1i} + \dots + \gamma_n w_{ni}$$

The RERI is calculated by [69]:

$$\text{RERI} = (e^{\beta_1 + \beta_2 + \beta_3} - 1) - (e^{\beta_1} - 1) - (e^{\beta_2} - 1) = (RR_{11} - 1) - (RR_{10} - 1) - (RR_{01} - 1) = RR_{11} - RR_{10} - RR_{01} + 1$$

This quantity represents the excess risk of the doubly exposed group ($RR_{11} - 1$) minus the excess risk from the singly exposed groups ($RR_{10} - 1$ and $RR_{01} - 1$), where β_{10} is the coefficient for the relative risk of the outcome associated with experiencing violence type 1, β_{01} is the coefficient for the relative risk of the outcome associated with experiencing violence type 2, and β_{11} is the coefficient for the relative risk of the outcome associated with the interaction between experiencing both types of violence.

The RERI can be interpreted as the increase in the relative risk of the outcome from exposure to both exposures, above and beyond the sum of the independent effects. A $\text{RERI} > 0$ indicates positive

additive interaction, while a RERI<0 indicates negative additive interaction. The same models used to calculate multiplicative interaction above were used to calculate the RERI as well. Looking across the models allows a holistic understanding of whether specific pairwise combinations of violence interact on the multiplicative or additive scales to synergistically produce excess HIV risk in the population.

Results

The number of people in each syndemic count tier is shown in Table 4. Lower-count tiers are more common, while highly polyvictimized tiers were less common.

Table 5.3: Number of types of violence experienced (N=754).

	Sample Prevalence (%)	Approximate sample size*
No violence	55.2	416
One type of violence	24.5	185
Two types of violence	12.2	92
Three types of violence	6.3	48
Four types of violence	1.9	14

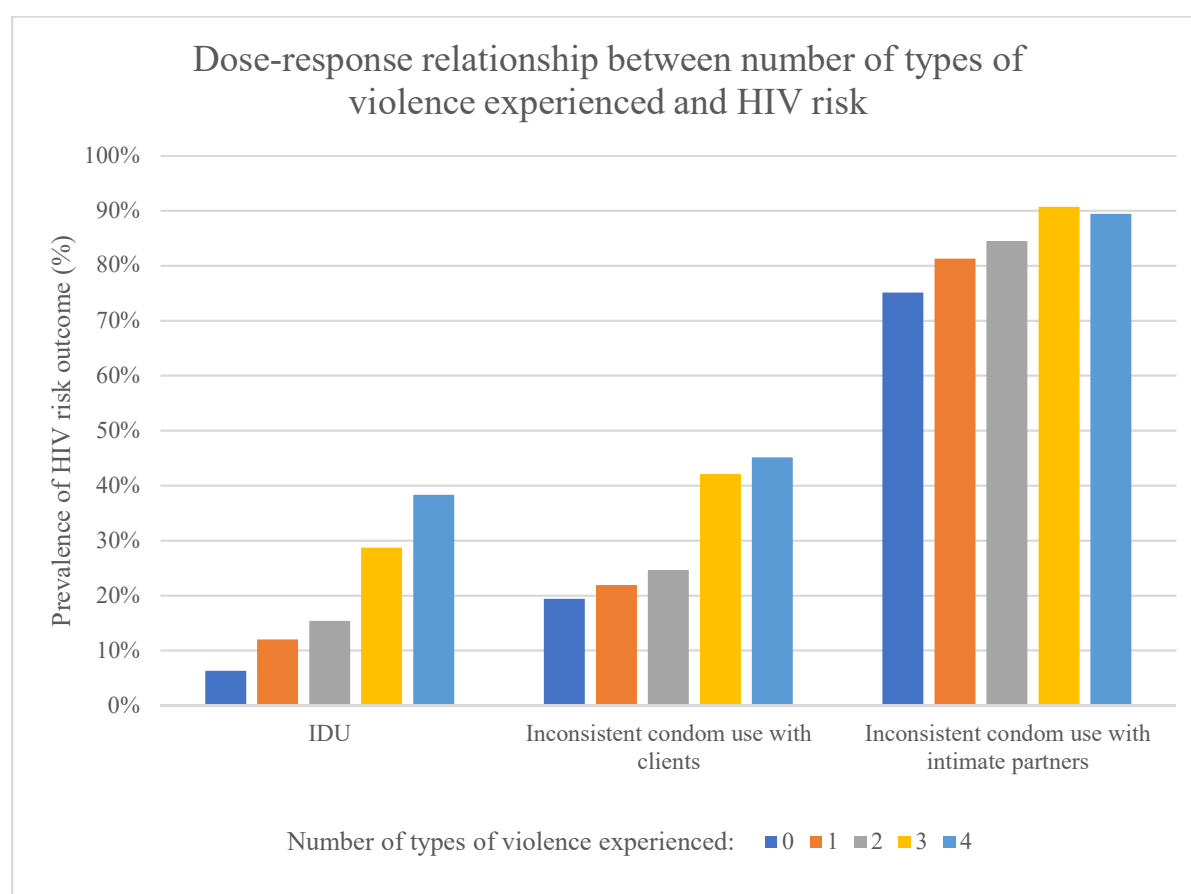
* Sample size varies slightly by imputation.

Linear and quadratic dose-response analyses

Descriptive analyses show that as the syndemic count increases, HIV risk also increases (Table 5; Figure 4). As the syndemic count increases from 0 to 4, the prevalence of injecting drug use rises from 6.3% to 38.3%. Compared to experiencing no violence, experiencing 2 types of violence (ARR 2.35, 95% CI 1.00, 5.51), 3 types of violence (ARR 3.22, 95% CI 1.14, 9.10) or 4 types of violence (ARR 2.88, 95% CI 1.02, 8.16) was significantly associated with injecting drug use. Similarly, the prevalence of inconsistent condom use with clients rises from 19.4% among those experiencing no violence to 45.1% among those experiencing 4 types of violence. Compared to those experiencing no violence, experiencing 3 types of violence (ARR 2.22, 95% CI 1.15, 4.26) or 4 types of violence (ARR 2.31, 95% CI 1.21, 4.42)

were significantly more likely to experience inconsistent condom use with clients. Finally, the prevalence of inconsistent condom use with intimate partners rises from 75.1% among those who experienced no violence to 89.4% among those who experienced all 4 types of violence, although the prevalence in the higher tiers were not significantly greater than the prevalence among those experiencing no violence at $p < 0.05$.

Figure 5.4: Prevalence of HIV risk outcomes by number of syndemic factors experienced.



Standard linear dose-response models (Table 5) show that for injecting drug use (ARR 1.37, 95% CI 1.04, 1.81), inconsistent condom use with clients (ARR 1.27, 95% CI 1.07, 1.49) and inconsistent condom use with intimate partners (ARR 1.04, 95% CI 1.01, 1.08), there is a significant linear trend where risk of each outcome increases as the syndemic count increases, even after controlling for

demographic confounders. Traditionally, this has often been used to argue that the syndemic factors constitute a synergistic epidemic.

However, quadratic dose-response tests (Table 5) demonstrated no significant synergism for injecting drug use (ARR 0.89, 95% CI 0.78, 1.03), inconsistent condom use with clients (ARR 1.00, 95% CI 0.93, 1.08), or inconsistent condom use with intimate partners (ARR 0.99, 95% CI 0.97, 1.01).

Table 5.4: Linear and quadratic dose-response analyses between number of types of violence and HIV risk outcomes.

Health outcome	Number of types of victimization	Approximate sample size (N) ¹	Prevalence of health outcome (%)	ARR (95% CI) ²
Injecting drug use (n=754)	0	416	6.3	1.0 (ref)
	1	185	12.0	2.02 (0.95, 4.28)
	2	92	15.4	2.35 (1.00, 5.51)*
	3	48	28.7	3.22 (1.14, 9.10)*
	4	14	38.3	2.88 (1.02, 8.16)*
	Total sample	754	10.7	
	<i>Linear dose-response</i>			1.37 (1.04, 1.81)*
	<i>Quadratic dose-response</i>			0.89 (0.78, 1.03)
Inconsistent condom use with clients (n=754)	0	416	19.4	1.0 (ref)
	1	185	21.9	1.23 (0.83, 1.82)
	2	92	24.6	1.54 (0.93, 2.54)
	3	48	42.1	2.22 (1.15, 4.26)*
	4	14	45.1	2.31 (1.21, 4.42)*
	Total sample	754	22.5	
	<i>Linear dose-response</i>			1.27 (1.07, 1.49)**
	<i>Quadratic dose-response</i>			1.00 (0.93, 1.08)
Inconsistent condom use with intimate partners (n=431)	0	260	75.1	1.0 (ref)
	1	96	81.3	1.08 (0.98, 1.18)
	2	49	84.5	1.11 (0.98, 1.26)
	3	19	90.7	1.14 (0.98, 1.33)
	4	6	89.4	1.12 (0.97, 1.29)
	Total sample	754	78.9	
	<i>Linear dose-response</i>			1.04 (1.01, 1.08)**
	<i>Quadratic dose-response</i>			0.99 (0.97, 1.01)

*p<0.05

**p<0.01

¹ Sample size varies slightly between imputations.

² Adjusted for participation in street sex work (binary), average number of vaginal or anal sex clients per day, having another source of income besides sex worker (binary), number of current intimate partners, number of years in sex work, educational level, age of entry into sex work, relationship status (categorical), and monthly salary.

Multiplicative and additive interaction analyses

In interaction analyses, no interaction coefficients (multiplicative interaction) or RERIs (additive interaction) were significant in the positive direction, for any pairwise combination of two violence types, for any health outcome of interest at the p<0.05 level of significance (Table 6). Full results from all interaction analyses are in the appendix.

Two violence combinations exhibited marginally significant negative synergy for the outcome of inconsistent condom use with intimate partners. There was marginally significant negative synergy between IPV and client violence on the multiplicative (ARR 0.87, 95% CI 0.75, 1.02, p=0.09) and additive (RERI -0.15, 95% CI -0.32, 0.03, p=0.10) scales. There was also marginally significant negative synergy between IPV and police violence on the multiplicative (ARR 0.86, 95% CI 0.73, 1.01, p=0.07) and additive (RERI -0.17, 95% CI -0.35, 0.02, p=0.08) scales.

Table 5.5: Summary of multiplicative and additive interaction analyses. Full results available in the appendix.

Health outcome	Victimization pattern	Multiplicative interaction ARR interaction term (95% CI)	p	Additive interaction RERI (95% CI)	p
Injecting drug use	IPV-client	0.42 (0.13, 1.38)	0.14	-1.28 (-4.52, 1.96)	0.42
	IPV-pimp	1.13 (0.34, 3.76)	0.84	-0.11 (-1.81, 1.59)	0.90
	IPV-police	1.04 (0.42, 2.58)	0.93	0.48 (-1.65, 2.62)	0.64
	client-pimp	0.95 (0.12, 7.79)	0.96	-0.79 (-2.75, 1.17)	0.41
	client-police	1.08 (0.30, 3.92)	0.91	0.47 (-2.07, 3.02)	0.71
	pimp-police	1.03 (0.28, 3.83)	0.96	-0.13 (-1.59, 1.33)	0.85
Inconsistent condom use with clients	IPV-client	1.17 (0.62, 2.21)	0.61	0.30 (-0.52, 1.13)	0.45
	IPV-pimp	1.01 (0.55, 1.86)	0.97	0.22 (-0.91, 1.36)	0.68
	IPV-police	0.78 (0.44, 1.39)	0.37	-0.23 (-1.19, 0.72)	0.61

	client-pimp	0.93 (0.36, 2.38)	0.89	0.02 (-1.45, 1.48)	0.98
	client-police	1.25 (0.76, 2.06)	0.36	0.45 (-0.17, 1.07)	0.14
	pimp-police	0.92 (0.48, 1.78)	0.80	0.08 (-1.02, 1.19)	0.89
Inconsistent condom use with intimate partners	IPV-client	0.87 (0.75, 1.02)	0.09	-0.15 (-0.32, 0.03)	0.10
	IPV-pimp	0.93 (0.73, 1.18)	0.52	-0.08 (-0.34, 0.18)	0.53
	IPV-police	0.86 (0.73, 1.01)	0.07	-0.17 (-0.35, 0.02)	0.08
	client-pimp	0.87 (0.61, 1.25)	0.43	-0.14 (-0.55, 0.25)	0.46
	client-police	1.04 (0.89, 1.21)	0.63	0.04 (-0.12, 0.21)	0.60
	pimp-police	1.11 (0.89, 1.39)	0.34	0.11 (-0.12, 0.34)	0.32

Discussion

As the number of types of violence experienced increases from 0 to 4, risk rises dramatically from 6.3% to 38.3% for injecting drug use, from 19.4% to 45.1% for inconsistent condom use with clients, and from 75.1% to 89.4% for inconsistent condom use with intimate partners. This finding demonstrates that client, police, intimate partner, and pimp violence cumulatively produce heightened HIV risk in the population using standard linear dose-response techniques. However, the remaining analyses in this chapter show no evidence that there is any significant positive synergistic interaction, on any scale, between any two types of violence on any HIV risk outcome.

We found significant results in the linear dose-response test, but negative results in the quadratic dose-response, multiplicative interaction, and additive interaction analyses. While the linear dose-response demonstrates a dramatically heightened risk of HIV-related outcomes as these violence experiences accumulate, the findings for all three synergy analyses fail to demonstrate synergy. These findings are a concrete example illustrating previous theoretical critiques[22] that epidemics that meet the traditional linear dose-response criteria for syndemics can fail to demonstrate quantitative evidence of synergistic interaction. We propose that the standard analyses in the field should incorporate the three analyses developed and implemented in this work (quadratic dose-response, multiplicative interaction, and additive interaction) to determine whether related or mutually reinforcing health issues truly rise to the level of a “synergistic epidemic.” These three approaches quantitatively test for synergy in three

different ways, operationalizing the concept of synergy in a nuanced way that will shed light on how potential syndemic factors do or do not synergistically produce excess health risk in a population.

Rather than revealing the positive synergism posited by syndemic theory, the results were more suggestive of negative synergistic interaction. Point estimates in quadratic dose-response analyses, while not significant at $p < 0.05$, were more suggestive of a plateau effect where risk levels off, rather than synergistically increases, at the highest syndemic tiers. For instance, with injecting drug use, the quadratic term was in the direction of a sub-additive trend (ARR 0.89, 95% CI 0.78, 1.03). For the outcome of inconsistent condom use with intimate partners, there were also marginally significant negative interaction effects observed between IPV and client violence (ARR 0.87, $p = 0.09$; RERI -0.15, $p = 0.10$) and between IPV and police violence (ARR 0.86, $p = 0.07$; RERI -0.17, $p = 0.08$) on both the multiplicative and additive scales. These findings are in line with other literature that has noted a plateau effect[72] and even significant negative interaction effects[73] between syndemic factors. This plateau effect may indicate that additional types of violence reach a ceiling in terms of ability to impact HIV risk pathways beyond which adding additional types of violence may not make a substantive difference for those outcomes. This may also mean that for highly polyvictimized individuals, more than one syndemic factor may have to be treated (or prevented) before any meaningful improvement in HIV risk is achieved. Combined with the concept in syndemic theory that syndemic factors are mutually reinforcing (which we demonstrated in Aim 1 by showing associations between violence types), negative synergy would make it particularly important for intervention packages to target multiple factors simultaneously.

Substance abuse, violence, and HIV – the components of the SAVA syndemic – remain vitally important issues for FSW, despite the lack of evidence in this analysis that violence types interact synergistically to produce excess HIV risk. As we found in the linear dose-response analysis, the cumulative effect of multiple types of violence on the health of sex workers is tremendous regardless of whether they interact synergistically. Linear dose-response analyses can compellingly show this increasing burden and motivate interventions to reduce violence from multiple sources in FSW, rather

than only reducing the frequency of a single type of violence. However, in cases where no synergism is observed, the amount of health burden is linearly proportional to the number of factors experienced and not in excess of that.

Analytic recommendations

Advancing our understanding of synergism in syndemics would be aided by uptake of the quadratic dose-response, multiplicative interaction, and additive interaction analyses in the syndemics literature. While some believe that additive interaction should be the standard based on the idea that additive interaction is more important than multiplicative interaction in a public health context,[22] currently there is no clear indication from theoretical language on syndemics which test is the sole best fit for operationalizing synergy. Thus all three approaches can be recommended wherever sufficient sample size make it appropriate. Use of all three methods can help build a picture of how frequently proposed “syndemics” meet each of these three tests for synergism.

Interaction analyses may be a high bar to clear to quantitatively demonstrate synergy due to large sample size requirements. In this analysis, we may have observed some synergistic effects had there been a larger sample size. We respond to this concern in a number of ways: 1) we use three different analyses to assess synergism, which is more sensitive than any one single analysis; 2) we looked at multiplicative and additive synergism for each pair of factors in a separate model rather than building a fully saturated model to increase power in each model to detect synergism; and 3) we developed the quadratic dose-response method that uses simplifying assumptions to reduce the number of model terms and increase power to detect synergism, at the expense of understanding differences between syndemic factors.

Implications for future research

These analytic proposals may also yield dividends in the highly related polyvictimization literature as well as some literatures that are slightly farther afield, such as intersectionality. Just as in the syndemics literature, dose-response obscures important differences between the different types of victimization ranging in seriousness from having parents divorce to being sexually abused.[33] While the language of “synergism” is less common in the polyvictimization literature, the critique still stands that standard dose-response analyses do not provide new information if each exposure is already shown to be individually associated with the outcome.[32] Going beyond dose-response analyses to look at quadratic trends or interactions between specific types of violence may therefore open up new understandings in the field.

The null findings on synergy should be interpreted in light of several limitations. We do not argue that there are no specifications or contexts in which SAVA is a synergistic epidemic, as it is possible that specifying different syndemic factors or outcomes within the SAVA umbrella may have resulted in a set of factors that do synergistically interact to produce excess risk of the outcome. Our model was unusual for making all four syndemic factors different types of violence. Other specifications of the model, e.g. ones in which drug use was another syndemic factor instead of an outcome, may have yielded different findings in synergism analyses. However, this specification was determined a priori based on theoretical interest in polyvictimization. We also note a valuable qualitative literature exists on syndemics[2] and acknowledge that syndemic factors may be experienced as synergistic in individuals’ lived experiences in ways that cannot always be reflected in a regression coefficient. More work should explore whether a synergistic effect is observed when using recent exposures rather than lifetime exposures. We chose to use lifetime exposures rather than recent exposures to violence as we conceptualized multiple forms of violence accumulating over the life course, placing an increasing cumulative burden on FSWs’ health. However, it is possible that there would be a stronger synergistic effect observed when examining *recent* violence, which temporally co-occurs within the same period. While syndemic theory as it was laid out does not explicitly require exposures to be recent or co-occurring, one might hypothesize stronger synergistic effects with temporal overlap between exposures. Information on frequency and intensity of

each of the violence exposures would also help contextualize the null findings on synergy. It is possible that more severe or frequent exposures would interact synergistically in a way that infrequent or less severe exposures do not. Longitudinal data would also be helpful understanding relationships between violence exposures and sexual and drug-related HIV risk outcome variables, given probable bidirectional causation.[74] Other limitations include not modeling associations between the three HIV risk outcomes examined. Structural equation modeling has increasingly been used in the syndemics literature[75] and may be helpful in understanding not just relationships between syndemic factors and between syndemic factors and outcomes, but also between the outcomes themselves.

Conclusion

Twenty years after the concept of syndemics was first laid out, the field stands at an exciting crossroads where the scope of social ills and conditions among a variety of marginalized populations under study is rapidly expanding and the rigor of analytic tools in use is sharpening. The tools proposed and demonstrated in this chapter can shine a clarifying light on the concept of synergism at the heart of syndemic theory. Empirical evidence of no synergy or negative synergy in a given syndemic would have important implications for how to structure interventions. The proposed analytic tools may be useful as the field grapples with whether to move forward with a smaller subset of epidemics that exhibit synergism, or instead consider a broader set of mutually causal, potentially non-synergistic epidemics shaped by social inequalities. Regardless, syndemic theory remains a powerful framework for preventing and treating complex epidemics in marginalized populations.

Appendix Tables

Table 5.A1: Interaction between client violence and IPV on the risk of injecting drug use.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of IPV
	% IDU	ARR (95% CI)	% IDU	ARR (95% CI)	
IPV=0	6.4%	1.0 (ref)	16.2%	2.78 (1.12, 6.91)*	2.70 (1.18, 6.20)*
IPV=1	11.9%	2.91 (0.95, 8.96)	25.0%	3.42 (1.46, 8.05)*	1.19 (0.36, 3.87)
ARR (95% CI) for IPV=1 vs IPV=0 within strata of client violence	---	2.37 (0.84, 6.71)	---	1.20 (0.62, 2.29)	---

Measure of interaction on multiplicative scale: 0.42 (0.13, 1.38), p=0.14

Measure of interaction on additive scale: RERI (95% CI): -1.28 (-4.52, 1.96), p=0.42

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A2: Interaction between client violence and IPV on the risk of inconsistent condom use with clients.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of IPV
	% ICU with clients	ARR (95% CI)	% ICU with clients	ARR (95% CI)	
IPV=0	21.1%	1.0 (ref)	21.4%	1.23 (0.75, 2.02)	1.27 (0.73, 2.19)
IPV=1	21.9%	1.22 (0.69, 2.17)	33.9%	1.75 (1.04, 2.95)*	1.31 (0.59, 2.88)
ARR (95% CI) for IPV=1 vs IPV=0 within strata of client violence	---	1.20 (0.70, 2.08)	---	1.39 (0.86, 2.24)	---

Measure of interaction on multiplicative scale: 1.17 (0.62, 2.21), p=0.61

Measure of interaction on additive scale: RERI (95% CI): 0.30 (-0.52, 1.13), p=0.45

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A3: Interaction between client violence and IPV on the risk of inconsistent condom use with intimate partners.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of IPV
	% ICU with partners	ARR (95% CI)	% ICU with partners	ARR (95% CI)	
IPV=0	75.2%	1.0 (ref)	82.6%	1.06 (0.96, 1.18)	
IPV=1	86.6%	1.17 (1.03, 1.33)*	86.4%	1.09 (0.99, 1.20)	
ARR (95% CI) for IPV=1 vs IPV=0 within strata of client violence	---		---		---

Measure of interaction on multiplicative scale: 0.87 (0.75, 1.02), p=0.09

Measure of interaction on additive scale: RERI (95% CI): -0.15 (-0.32, 0.03), p=0.10

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

† Estimation sample varies between imputations; strata-specific models cannot be run

Table 5.A4: Interaction between client violence and police violence on the risk of injecting drug use.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of police violence
	% IDU	ARR (95% CI)	% IDU	ARR (95% CI)	
Police violence=0	6.5%	1.0 (ref)	13.3%	2.50 (1.06, 5.87)*	2.14 (0.93, 4.95)
Police violence=1	10.3%	1.17 (0.45, 3.09)	32.7%	3.15 (1.25, 7.92)*	3.90 (0.99, 15.41)
ARR (95% CI) for police=1 vs police=0 within strata of client violence	---	1.29 (0.48, 3.48)	---	1.17 (0.60, 2.29)	---

Measure of interaction on multiplicative scale: 1.08 (0.30, 3.92), p=0.91

Measure of interaction on additive scale: RERI (95% CI): 0.47 (-2.07, 3.02), p=0.71

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A5: Interaction between client violence and police violence on the risk of inconsistent condom use with clients.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of police violence
	% ICU with clients	ARR (95% CI)	% ICU with clients	ARR (95% CI)	
Police violence=0	19.5%	1.0 (ref)	18.0%	1.15 (0.65, 2.04)	1.20 (0.66, 2.18)
Police violence=1	36.4%	1.39 (0.97, 2.00)	43.1%	2.00 (1.27, 3.13)**	0.85 (0.45, 1.61)
ARR (95% CI) for police=1 vs police=0 within strata of client violence	---	1.41 (1.01, 1.95)*	---	1.66 (0.86, 3.21)	---

Measure of interaction on multiplicative scale: 1.25 (0.76, 2.06), p=0.36

Measure of interaction on additive scale: RERI (95% CI): 0.45 (-0.17, 1.07), p=0.14

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A6: Interaction between client violence and police violence on the risk of inconsistent condom use with intimate partners.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of police violence
	% ICU with partners	ARR (95% CI)	% ICU with partners	ARR (95% CI)	
Police violence=0	75.5%	1.0 (ref)	79.4%	1.02 (0.91, 1.14)	
Police violence=1	83.1%	1.08 (0.95, 1.23)	92.1%	1.14 (1.03, 1.25)**	
ARR (95% CI) for police=1 vs police=0 within strata of client violence	---		---		---

Measure of interaction on multiplicative scale: 1.04 (0.89, 1.21), p=0.63

Measure of interaction on additive scale: RERI (95% CI): 0.04 (-0.12, 0.21), p=0.60

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

† Estimation sample varies between imputations; strata-specific models cannot be run

Table 5.A7: Interaction between client violence and pimp violence on the risk of injecting drug use.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of pimp violence
	% IDU	ARR (95% CI)	% IDU	ARR (95% CI)	
Pimp violence=0	6.9%	1.0 (ref)	19.6%	3.05 (1.38, 6.74)**	2.81 (1.29, 6.15)*
Pimp violence=1	5.2%	0.67 (0.08, 5.29)	17.9%	1.93 (0.71, 5.27)	3.20 (0.68, 15.02)
ARR (95% CI) for pimp =1 vs pimp=0 within strata of client violence	---	0.56 (0.05, 5.84)	---	0.74 (0.39, 1.43)	---

Measure of interaction on multiplicative scale: 0.95 (0.12, 7.79), p=0.96

Measure of interaction on additive scale: RERI (95% CI): -0.79 (-2.75, 1.17), p=0.41

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A8: Interaction between client violence and pimp violence on the risk of inconsistent condom use with clients.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of pimp violence
	% ICU with clients	ARR (95% CI)	% ICU with clients	ARR (95% CI)	
Pimp violence=0	21.1%	1.0 (ref)	23.8%	1.31 (0.79, 2.18)	1.27 (0.78, 2.09)
Pimp violence=1	20.9%	1.48 (0.70, 3.13)	30.0%	1.81 (0.99, 3.33)	1.54 (0.46, 5.19)
ARR (95% CI) for pimp =1 vs pimp=0 within strata of client violence	---	1.65 (0.79, 3.49)	---	1.25 (0.74, 2.10)	---

Measure of interaction on multiplicative scale: 0.93 (0.36, 2.38), p=0.89

Measure of interaction on additive scale: RERI (95% CI): 0.02 (-1.45, 1.48), p=0.98

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A9: Interaction between client violence and pimp violence on the risk of inconsistent condom use with intimate partners.

	Client violence=0		Client violence=1		ARR (95% CI) for Client=1 vs Client=0 within strata of pimp violence
	% ICU with partners	ARR (95% CI)	% ICU with partners	ARR (95% CI)	
Pimp violence=0	76.0%	1.0 (ref)	83.7%	1.07 (0.96, 1.18)	
Pimp violence=1	88.9%	1.12 (0.82, 1.54)	84.4%	1.04 (0.95, 1.14)	
ARR (95% CI) for pimp =1 vs pimp=0 within strata of client violence	---		---		---

Measure of interaction on multiplicative scale: 0.87 (0.61, 1.25), p=0.43

Measure of interaction on additive scale: (95% CI): -0.15 (-0.55, 0.25), p=0.46

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

† Estimation sample varies between imputations; strata-specific models cannot be run

Table 5.A10: Interaction between police violence and IPV on the risk of injecting drug use.

	Police violence=0		Police violence=1		ARR (95% CI) for Police=1 vs Police=0 within strata of IPV
	% IDU	ARR (95% CI)	% IDU	ARR (95% CI)	
IPV=0	7.7%	1.0 (ref)	16.9%	1.45 (0.84, 2.50)	1.41 (0.84, 2.38)
IPV=1	12.3%	1.87 (0.89, 3.90)	38.9%	2.81 (1.13, 7.01)*	1.67 (0.67, 4.18)
ARR (95% CI) for IPV=1 vs IPV=0 within strata of police violence	---	1.74 (0.83, 3.66)	---	2.23 (0.99, 5.03)	---

Measure of interaction on multiplicative scale: 1.04 (0.42, 2.58), p=0.93

Measure of interaction on additive scale: RERI (95% CI): 0.48 (-1.65, 2.62), p=0.64

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A11: Interaction between police violence and IPV on the risk of inconsistent condom use with clients.

	Police violence=0		Police violence=1		ARR (95% CI) for Police=1 vs Police=0 within strata of IPV
	% ICU with clients	ARR (95% CI)	% ICU with clients	ARR (95% CI)	
IPV=0	18.6%	1.0 (ref)	37.7%	1.66 (1.20, 2.29)**	1.72 (1.26, 2.35)**
IPV=1	22.4%	1.48 (0.90, 2.43)	46.5%	1.91 (1.11, 3.30)*	1.06 (0.51, 2.18)
ARR (95% CI) for IPV=1 vs IPV=0 within strata of police violence	---	1.50 (0.89, 2.54)	---	1.13 (0.73, 1.75)	---

Measure of interaction on multiplicative scale: 0.78 (0.44, 1.39), p=0.37

Measure of interaction on additive scale: RERI (95% CI): -0.23 (-1.19, 0.72), p=0.61

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A12 Interaction between police violence and IPV on the risk of inconsistent condom use with intimate partners.

	Police violence=0		Police violence=1		ARR (95% CI) for Police=1 vs Police=0 within strata of IPV
	% ICU with partners	ARR (95% CI)	% ICU with partners	ARR (95% CI)	
IPV=0	74.9%	1.0 (ref)	88.9%	1.14 (1.04, 1.25)*	
IPV=1	85.7%	1.14 (1.02, 1.26)	87.9%	1.11 (0.97, 1.26)	
ARR (95% CI) for IPV=1 vs IPV=0 within strata of police violence	---		---		---

Measure of interaction on multiplicative scale: 0.86 (0.73, 1.01), p=0.07

Measure of interaction on additive scale: (95% CI): -0.17 -0.35, 0.02), p=0.08

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

† Estimation sample varies between imputations; strata-specific models cannot be run

Table 5.A13: Interaction between police violence and pimp violence on the risk of injecting drug use.

	Police violence=0		Police violence=1		ARR (95% CI) for Police=1 vs Police=0 within strata of pimp violence
	% IDU	ARR (95% CI)	% IDU	ARR (95% CI)	
Pimp=0	8.4%	1.0 (ref)	21.9%	1.79 (1.00, 3.21)	1.73 (0.91, 3.30)
Pimp=1	7.3%	0.78 (0.25, 2.39)	28.6%	1.44 (0.62, 3.32)	2.89 (0.44, 19.07) [†]
ARR (95% CI) for pimp=1 vs pimp=0 within strata of police violence	---	0.72 (0.21, 2.45)	---	1.06 (0.49, 2.31)	---

Measure of interaction on multiplicative scale: 1.03 (0.28, 3.83), p=0.96

Measure of interaction on additive scale: RERI (95% CI): -0.13 (-1.59, 1.33), p=0.85

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

[†] Not adjusted for relationship status; no one who was legally married/divorced and no one who was divorced/separated had the outcome of IDU. Model did not converge with relationship status included.

Table 5.A14: Interaction between police violence and pimp violence on the risk of inconsistent condom use with clients.

	Police violence=0		Police violence=1		ARR (95% CI) for Police=1 vs Police=0 within strata of pimp violence
	% ICU with clients	ARR (95% CI)	% ICU with clients	ARR (95% CI)	
Pimp=0	19.1%	1.0 (ref)	39.6%	1.60 (1.15, 2.22)**	1.57 (1.17, 2.11)**
Pimp=1	19.4%	1.44 (0.74, 2.80)	42.8%	2.12 (1.24, 3.64)**	1.97 (1.01, 3.82)*
ARR (95% CI) for pimp=1 vs pimp=0 within strata of police violence	---	1.63 (0.81, 3.28)	---	0.94 (0.59, 1.48)	---

Measure of interaction on multiplicative scale: 0.92 (0.48, 1.78), p=0.80

Measure of interaction on additive scale: RERI (95% CI): 0.08 (-1.02, 1.19), p=0.89

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A15: Interaction between police violence and pimp violence on the risk of inconsistent condom use with intimate partners.

	Police violence=0		Police violence=1		ARR (95% CI) for Police=1 vs Police=0 within strata of pimp violence
	% ICU with partners	ARR (95% CI)	% ICU with partners	ARR (95% CI)	
Pimp=0	76.5%	1.0 (ref)	85.8%	1.08 (0.97, 1.21)	
Pimp=1	77.0%	0.97 (0.82, 1.13)	95.7%	1.16 (1.06, 1.27)**	
ARR (95% CI) for pimp=1 vs pimp=0 within strata of police violence	---		---		---

Measure of interaction on multiplicative scale: 1.11 (0.89, 1.39), p=0.34

Measure of interaction on additive scale: RERI (95% CI): 0.11 (-0.12, 0.34), p=0.32

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

† Estimation sample varies between imputations; strata-specific models cannot be run

Table 5.A16: Interaction between IPV and pimp violence on the risk of injecting drug use.

	IPV violence=0		IPV violence=1		ARR (95% CI) for IPV=1 vs IPV=0 within strata of pimp violence
	% IDU	ARR (95% CI)	% IDU	ARR (95% CI)	
Pimp=0	8.8%	1.0 (ref)	18.8%	2.16 (1.00, 4.64)*	2.07 (0.93, 4.61)
Pimp=1	9.4%	0.75 (0.27, 2.05)	26.8%	1.81 (0.80, 4.10)	2.43 (0.59, 10.04)†
ARR (95% CI) for pimp=1 vs pimp=0 within strata of IPV	---	0.67 (0.21, 2.08)	---	0.90 (0.35, 2.34)	---

Measure of interaction on multiplicative scale: 1.13 (0.34, 3.76), p=0.84

Measure of interaction on additive scale: RERI (95% CI): -0.11 (-1.81, 1.59), p=0.90

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

† Not adjusted for relationship status; no one who was legally married/divorced and no one who was divorced/separated had the outcome of IDU. Model did not converge with relationship status included.

Table 5.A17: Interaction between IPV and pimp violence on the risk of inconsistent condom use with clients.

	IPV violence=0		IPV violence=1		ARR (95% CI) for IPV=1 vs IPV=0 within strata of pimp violence
	% ICU with clients	ARR (95% CI)	% ICU with clients	ARR (95% CI)	
Pimp=0	20.9%	1.0 (ref)	27.9%	1.42 (0.93, 2.17)	1.38 (0.93, 2.06)
Pimp=1	23.8%	1.46 (0.89, 2.41)	36.6%	2.10 (1.17, 3.77)*	1.53 (0.74, 3.16)
ARR (95% CI) for pimp=1 vs pimp=0 within strata of IPV	---	1.52 (0.91, 2.56)	---	1.11 (0.61, 2.02)	---

Measure of interaction on multiplicative scale: 1.01 (0.55, 1.86), $p=0.97$

Measure of interaction on additive scale: RERI (95% CI): 0.22 (-0.91, 1.36), $p=0.68$

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

Table 5.A18: Interaction between IPV and pimp violence on the risk of inconsistent condom use with intimate partners.

	IPV violence=0		IPV violence=1		ARR (95% CI) for IPV=1 vs IPV=0 within strata of pimp violence
	% ICU with partners	ARR (95% CI)	% ICU with partners	ARR (95% CI)	
Pimp=0	76.3%	1.0 (ref)	86.2%	1.11 (1.01, 1.22)*	
Pimp=1	84.2%	1.04 (0.94, 1.16)	87.5%	1.08 (0.91, 1.27)	
ARR (95% CI) for pimp=1 vs pimp=0 within strata of IPV			---		---

Measure of interaction on multiplicative scale: 0.93 (0.73, 1.18), $p=0.52$

Measure of interaction on additive scale: RERI (95% CI): -0.08 (-0.34, 0.18), $p=0.53$

ARRs are adjusted for: lifetime police violence, lifetime pimp violence, age, street vs nonstreet sex work, average # of clients per night with whom you have vaginal or anal sex, having another income vs. none, current number of non-paying partners, education, age of entry into sex work, relationship status (never married, dating, living together as married, legally married or widowed, divorced or separated), and monthly salary (continuous)

† Estimation sample varies between imputations; strata-specific models cannot be run

References

1. Singer M. A dose of drugs, a touch of violence, a case of AIDS: conceptualizing the SAVA syndemic. *Free Inquiry in Creative Sociology*. 1996;24(2):99-110.
2. Romero-Daza N, Weeks M, Singer M. "Nobody gives a damn if I live or die": violence, drugs, and street-level prostitution in inner-city Hartford, Connecticut. *Medical anthropology*. 2003;22(3):233-59.
3. Singer M, Clair S. Syndemics and public health: Reconceptualizing disease in bio-social context. *Medical anthropology quarterly*. 2003;17(4):423-41.
4. Sharma AS-A. Syndemics: health in context.
5. Singer M. Introduction to syndemics: A critical systems approach to public and community health: John Wiley & Sons; 2009.
6. Tsai AC, Mendenhall E, Trostle JA, Kawachi I. Co-occurring epidemics, syndemics, and population health. *The Lancet*. 2017;389(10072):978-82.
7. Meyer JP, Springer SA, Altice FL. Substance abuse, violence, and HIV in women: a literature review of the syndemic. *Journal of Women's Health*. 2011;20(7):991-1006.
8. Baral S, Beyrer C, Muessig K, Poteat T, Wirtz AL, Decker MR, et al. Burden of HIV among female sex workers in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet infectious diseases*. 2012;12(7):538-49.
9. Rekart ML. Sex-work harm reduction. *The Lancet*. 2006;366(9503):2123-34.
10. Decker MR, Crago A-L, Chu SK, Sherman SG, Seshu MS, Buthelezi K, et al. Human rights violations against sex workers: burden and effect on HIV. *The Lancet*. 2014.
11. Campbell JC, Baty M, Ghandour RM, Stockman JK, Francisco L, Wagman J. The intersection of intimate partner violence against women and HIV/AIDS: a review. *International journal of injury control and safety promotion*. 2008;15(4):221-31.
12. Gielen AC, Ghandour RM, Burke JG, Mahoney P, McDonnell KA, O'Campo P. HIV/AIDS and Intimate Partner Violence Intersecting Women's Health Issues in the United States. *Trauma, Violence, & Abuse*. 2007;8(2):178-98.
13. Chersich M, Luchters S, Malonza I, Mwarogo P, King'Ola N, Temmerman M. Heavy episodic drinking among Kenyan female sex workers is associated with unsafe sex, sexual violence and sexually transmitted infections. *International journal of STD & AIDS*. 2007;18(11):764-9.
14. Odinokova V, Rusakova M, Urada LA, Silverman JG, Raj A. Police sexual coercion and its association with risky sex work and substance use behaviors among female sex workers in St. Petersburg and Orenburg, Russia. *International Journal of Drug Policy*. 2014;25(1):96-104.
15. Ulibarri MD, Strathdee SA, Ulloa EC, Lozada R, Fraga MA, Magis-Rodríguez C, et al. Injection drug use as a mediator between client-perpetrated abuse and HIV status among female sex workers in two Mexico-US border cities. *AIDS and Behavior*. 2011;15(1):179-85.
16. Decker MR, Wirtz AL, Baral SD, Peryshkina A, Mogilnyi V, Weber RA, et al. Injection drug use, sexual risk, violence and STI/HIV among Moscow female sex workers. *Sexually transmitted infections*. 2012;88(4):278-83.
17. Argento E, Muldoon KA, Duff P, Simo A, Deering KN, Shannon K. High prevalence and partner correlates of physical and sexual violence by intimate partners among street and off-street sex workers. *PloS one*. 2014;9(7):e102129.
18. Braunstein SL, Ingabire CM, Geubbels E, Vyankandondera J, Umulisa M-M, Gahiro E, et al. High burden of prevalent and recently acquired HIV among female sex workers and female HIV voluntary testing center clients in Kigali, Rwanda. *PloS one*. 2011;6(9):e24321.
19. Decker MR, Wirtz AL, Moguilnyi V, Peryshkina A, Ostrovskaya M, Nikita M, et al. Female sex workers in three cities in Russia: HIV prevalence, risk factors and experience with targeted HIV prevention. *AIDS and behavior*. 2014;18(3):562-72.

20. Jewkes RK, Dunkle K, Nduna M, Shai N. Intimate partner violence, relationship power inequity, and incidence of HIV infection in young women in South Africa: a cohort study. *The Lancet*. 2010;376(9734):41-8.
21. Decker MR, Pearson E, Illangasekare SL, Clark E, Sherman SG. Violence against women in sex work and HIV risk implications differ qualitatively by perpetrator. *BMC public health*. 2013;13(1):876.
22. Tsai AC, Burns BF. Syndemics of psychosocial problems and HIV risk: a systematic review of empirical tests of the disease interaction concept. *Social Science & Medicine*. 2015;139:26-35.
23. Bauer GR. Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity. *Social science & medicine*. 2014;110:10-7.
24. Blot WJ, Day NE. Synergism and interaction: are they equivalent? *American Journal of Epidemiology*. 1979;110(1):99-100.
25. Jie W, Ciyong L, Xueqing D, Hui W, Lingyao H. A syndemic of psychosocial problems places the MSM (men who have sex with men) population at greater risk of HIV infection. *PloS one*. 2012;7(3):e32312.
26. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *American journal of public health*. 2003;93(6):939-42.
27. Parsons JT, Grov C, Golub SA. Sexual compulsivity, co-occurring psychosocial health problems, and HIV risk among gay and bisexual men: further evidence of a syndemic. *American Journal of Public Health*. 2012;102(1):156-62.
28. Oldenburg CE, Perez-Brumer AG, Reisner SL. Poverty matters: contextualizing the syndemic condition of psychological factors and newly diagnosed HIV infection in the United States. *AIDS*. 2014;28(18):2763-9.
29. Felitti M, Vincent J, Anda M, Robert F, Nordenberg M, Williamson M, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American journal of preventive medicine*. 1998;14(4):245-58.
30. Egan JE, Frye V, Kurtz SP, Latkin C, Chen M, Tobin K, et al. Migration, neighborhoods, and networks: approaches to understanding how urban environmental conditions affect syndemic adverse health outcomes among gay, bisexual and other men who have sex with men. *AIDS and Behavior*. 2011;15(1):35-50.
31. Brennan J, Kuhns LM, Johnson AK, Belzer M, Wilson EC, Garofalo R. Syndemic theory and HIV-related risk among young transgender women: the role of multiple, co-occurring health problems and social marginalization. *American journal of public health*. 2012;102(9):1751-7.
32. Tsai AC, Venkataramani AS. Syndemics and health disparities: a methodological note. *AIDS and Behavior*. 2016;20(2):423-30.
33. Finkelhor D, Shattuck A, Turner H, Hamby S. Improving the adverse childhood experiences study scale. *JAMA pediatrics*. 2013;167(1):70-5.
34. Illangasekare SL. The role of the intimate partner violence, HIV, and substance abuse syndemic in women's mental health: The Johns Hopkins University; 2011.
35. Illangasekare S, Burke J, Chander G, Gielen A. The syndemic effects of intimate partner violence, HIV/AIDS, and substance abuse on depression among low-income urban women. *Journal of Urban Health*. 2013;90(5):934-47.
36. Herrick A. Syndemic processes among young men who have sex with men (MSM): Pathways toward risk and resilience: University of Pittsburgh; 2011.
37. USAID. HIV/AIDS Health Profile: Europe and Eurasia Region. 2012.
38. UNAIDS. Report on the Global AIDS Epidemic. Geneva: 2012.
39. Clark F. Gaps remain in Russia's response to HIV/AIDS. *The Lancet*. 2016;388(10047):857.
40. Pokrovskiy V, Ladnaya N, Tushina O, Buravtsova E. HIV-Infection. Informational Bulletin #40 (ВИЧ-Инфекция. Информационный бюллетень №40). Moscow: Federal Scientific and Methodological Center for AIDS Prevention and Control (Федеральный научно-методический центр по профилактике и борьбе со СПИДом), 2015.

41. European Centre for Disease Prevention and Control, WHO Regional Office for Europe. HIV/AIDS surveillance in Europe 2015. Stockholm:: 2016.
42. UNAIDS. Country Progress Report of the Russian Federation on the Implementation of the Declaration of Commitment on HIV/AIDS. Moscow: 2008.
43. Cohen J. Praised russian prevention program faces loss of funds. *Science*. 2010;329(5988):168-.
44. United States Department of State. International Narcotics Control Strategy Report. 2014.
45. Ward H, Aral S. Globalisation, the sex industry, and health. *Sexually transmitted infections*. 2006;82(5):345-7.
46. Heckathorn DD. Respondent-driven sampling: a new approach to the study of hidden populations. *Social problems*. 1997:174-99.
47. Straus MA, Hamby SL, Boney-McCoy S, Sugarman DB. The revised conflict tactics scales (CTS2) development and preliminary psychometric data. *Journal of family issues*. 1996;17(3):283-316.
48. World Health Organization UNPF, Joint United Nations Programme on HIV/AIDS, Global Network, of Sex Work Projects TWB. Implementing comprehensive HIV/STI programmes with sex workers: practical approaches from collaborative interventions. Geneva: World Health Organization, 2013.
49. Carlson CE, Chen J, Chang M, Batsukh A, Toivgoos A, Riedel M, et al. Reducing Intimate and Paying Partner Violence Against Women Who Exchange Sex in Mongolia Results From a Randomized Clinical Trial. *Journal of interpersonal violence*. 2012;27(10):1911-31.
50. Gupta J, Reed E, Kershaw T, Blankenship KM. History of sex trafficking, recent experiences of violence, and HIV vulnerability among female sex workers in coastal Andhra Pradesh, India. *International Journal of Gynecology & Obstetrics*. 2011;114(2):101-5.
51. Su S, Li X, Zhang L, Lin D, Zhang C, Zhou Y. Age group differences in HIV risk and mental health problems among female sex workers in Southwest China. *AIDS care*. 2014;26(8):1019-26.
52. Sarkar K, Bal B, Mukherjee R, Saha MK, Chakraborty S, Niyogi SK, et al. Young age is a risk factor for HIV among female sex workers—an experience from India. *Journal of Infection*. 2006;53(4):255-9.
53. El-Bassel N, Witte SS, Wada T, Gilbert L, Wallace J. Correlates of partner violence among female street-based sex workers: substance abuse, history of childhood abuse, and HIV risks. *AIDS patient care and STDs*. 2001;15(1):41-51.
54. Shannon K, Rusch M, Shoveller J, Alexson D, Gibson K, Tyndall MW. Mapping violence and policing as an environmental–structural barrier to health service and syringe availability among substance-using women in street-level sex work. *International Journal of Drug Policy*. 2008;19(2):140-7.
55. Dandona R, Dandona L, Gutierrez JP, Kumar AG, McPherson S, Samuels F, et al. High risk of HIV in non-brothel based female sex workers in India. *BMC Public Health*. 2005;5(1):87.
56. Wirtz A, Peryshkina A, Moguilnyi V, Beyrer C, Decker M. Current and recent drug use intensifies sexual and structural HIV risk outcomes among female sex workers in the Russian Federation. *International Journal of Drug Policy*. 2015.
57. Panchanadeswaran S, Johnson SC, Sivaram S, Srikrishnan AK, Latkin C, Bentley ME, et al. Intimate partner violence is as important as client violence in increasing street-based female sex workers' vulnerability to HIV in India. *International Journal of Drug Policy*. 2008;19(2):106-12.
58. Hong Y, Zhang C, Li X, Liu W, Zhou Y. Partner violence and psychosocial distress among female sex workers in China. *PloS one*. 2013;8(4):e62290.
59. Goldenberg SM, Rangel G, Vera A, Patterson TL, Abramovitz D, Silverman JG, et al. Exploring the impact of underage sex work among female sex workers in two Mexico–US border cities. *AIDS and Behavior*. 2012;16(4):969-81.
60. Lang DL, Salazar LF, DiClemente RJ, Markosyan K. Gender based violence as a risk factor for HIV-associated risk behaviors among female sex workers in Armenia. *AIDS and Behavior*. 2013;17(2):551-8.
61. Karandikar S, Gezinski LB. Intimate partner violence and HIV risks among female sex workers of Mumbai, India. *Journal of Ethnic And Cultural Diversity in Social Work*. 2013;22(2):112-28.

62. Weine S, Golobof A, Bahromov M, Kashuba A, Kalandarov T, Jonbekov J, et al. Female migrant sex workers in Moscow: gender and power factors and HIV risk. *Women & health*. 2013;53(1):56-73.
63. UNAIDS. Global AIDS response progress reporting 2014: construction of core indicators for monitoring the 2011 UN political declaration on HIV/AIDS. 2014.
64. Deering KN, Bhattacharjee P, Bradley J, Moses SS, Shannon K, Shaw SY, et al. Condom use within non-commercial partnerships of female sex workers in southern India. *BMC public health*. 2011;11(Suppl 6):S11.
65. Murray L, Moreno L, Rosario S, Ellen J, Sweat M, Kerrigan D. The role of relationship intimacy in consistent condom use among female sex workers and their regular paying partners in the Dominican Republic. *AIDS and Behavior*. 2007;11(3):463-70.
66. Voeten H, Egesah O, Varkevisser C, Habbema J. Female sex workers and unsafe sex in urban and rural Nyanza, Kenya: regular partners may contribute more to HIV transmission than clients. *Tropical Medicine & International Health*. 2007;12(2):174-82.
67. Peitzmeier S, Mason K, Ceesay N, Diouf D, Drame F, Loum J, et al. A cross-sectional evaluation of the prevalence and associations of HIV among female sex workers in the Gambia. *International journal of STD & AIDS*. 2013;0956462413498858.
68. Szklo M, Nieto FJ. *Epidemiology: beyond the basics*: Jones & Bartlett Publishers; 2012.
69. VanderWeele T. *Explanation in causal inference: methods for mediation and interaction*: Oxford University Press; 2015.
70. Skrdal A. Interaction as departure from additivity in case-control studies: a cautionary note. *American Journal of Epidemiology*. 2003;158(3):251-8.
71. Knol MJ, VanderWeele TJ. Recommendations for presenting analyses of effect modification and interaction. *International journal of epidemiology*. 2012;41(2):514-20.
72. Guadamuz T, McCarthy K, Wimonasate W, Thienkrua W, Varangrat A, Chaikummao S, et al. Psychosocial health conditions and HIV prevalence and incidence in a cohort of men who have sex with men in Bangkok, Thailand: Evidence of a syndemic effect. *AIDS and Behavior*. 2014;18(11):2089-96.
73. Gebrekristos HT. Risk alcohol drinking and sexual behavior among homosexual and bisexual men in the United States 2010.
74. El-Bassel N, Gilbert L, Wu E, Go H, Hill J. Relationship between drug abuse and intimate partner violence: a longitudinal study among women receiving methadone. *American Journal of Public Health*. 2005;95(3):465-70.
75. Mustanski B, Andrews R, Herrick A, Stall R, Schnarrs PW. A syndemic of psychosocial health disparities and associations with risk for attempting suicide among young sexual minority men. *American journal of public health*. 2014;104(2):287-94.

6. Conclusions

Taken together, the dissertation urges greater nuance in syndemic and polyvictimization analyses, and greater attention to multiple forms of violence in HIV and violence prevention interventions for FSW.

Review of results

In Aim 1 (Chapter 3), we showed that lifetime violence is prevalent, with 44.8% experiencing any type of violence, including 31.7% from clients, 16.0% from police, 15.7% from intimate partners, and 11.4% from pimps. One-fifth (20.4%) of participants experienced two or more types (i.e. polyvictimization). Client violence was central to polyvictimization: 94.1% of polyvictims experienced client violence. In comparison, polyvictimization frequently occurs without IPV, pimp, or police violence. Police, pimp, or intimate partner violence co-occur less than would be expected by chance when client violence is not present ($p < 0.001$), but co-occur more than would be expected by chance when client violence is present. In bivariate regression analyses, every type of violence was associated with every other type of violence, demonstrating that violence types, i.e. syndemic factors, cluster. However, after adjusting for all forms of violence in each model, only client violence retained strong independent associations with the other three forms of violence. After adjusting for other types of violence and demographic factors, experiencing client violence is independently associated with police violence (ARR=2.77, 95% CI 1.67, 4.59), IPV (ARR=3.67, 95% CI 1.95, 6.89), and pimp violence (ARR=5.26, 95% CI 2.80, 9.86). Client violence is more strongly associated with IPV, pimp violence, and police violence than nearly any other demographic or sex work context variable measured. A cluster analysis was conducted to understand common polyvictimization profiles, but clusters were difficult to interpret and not highly distinct from one another. Further analyses using cluster membership were therefore not implemented in later chapters.

In Aim 2 (Chapter 4), we assessed associations between 4 major types of violence and 3 major sources of HIV risk in FSW. To our knowledge, this is one of the first manuscripts to assess violence and

HIV risk so comprehensively. Sources of HIV risk were prevalent, with 10.7% recently injecting drugs, 45.1% engaging in inconsistent condom use with intimate partners, and 22.5% engaging in inconsistent condom use with clients. After adjusting for demographic confounders, intimate partner violence (IPV) (ARR 2.12, 95% CI 1.10, 4.10) and client violence (ARR 2.75, 95% CI 1.19, 6.32) were predictive of injecting drug use, IPV (ARR 1.10, 95% CI 1.01, 1.19) and police violence (ARR 1.11, 95% CI 1.01, 1.21) were associated with inconsistent condom use with intimate partners, and IPV (ARR 1.49, 95% CI 1.02, 2.17) and police violence (ARR 1.65, 95% CI 1.19, 2.29) were associated with inconsistent condom use with clients. Most associations attenuated when multiple forms of violence were included in the same model. In models that adjusted for all four forms of violence, only client violence (ARR 2.44, 95% CI 1.06, 5.60) was associated with drug use, and only police violence (ARR 1.47, 95% CI 1.09, 1.98) was associated with inconsistent condom use with clients at $p < 0.05$.

In Aim 3 (Chapter 5), we propose and implement a comprehensive set of methods to quantitatively test for synergism between a set of potential syndemic factors. As the number of types of violence experienced increases from 0 to 4, risk rises dramatically from 6.3% to 38.3% for injecting drug use, from 19.4% to 45.1% for inconsistent condom use with clients, and from 75.1% to 89.4% for inconsistent condom use with intimate partners. Standard linear dose-response analyses showed a statistically significant association between the number of types of violence experienced and injecting drug use (ARR 1.37, 95% CI 1.04, 1.81), inconsistent condom use with clients (ARR 1.27, 95% CI 1.07, 1.49), and inconsistent condom use with intimate partners (ARR 1.04, 95% CI 1.01, 1.08). Because standard linear dose-response analysis does not operationalize synergism, we implemented quadratic dose-response, multiplicative interaction, and additive interaction analyses; all had null findings for synergism for all outcomes and violence types. These results demonstrate that a set of factors that meet standard analytic criteria (linear dose-response) for constituting a “synergistic epidemic” may not actually demonstrate synergism in statistical tests designed specifically to test for synergism. The linear dose-response results compellingly show how risks to health accumulate as the number of types of violence

experienced increases, but should not be confused with demonstrating synergistic interaction between multiple types of violence.

Implications for HIV and violence interventions and research

If future longitudinal studies corroborate the hypothesis from Aim 1 that client violence is a central driver of the other three types of violence among FSW, then interventions to address any type of violence should also incorporate client violence prevention. Violence prevention interventions may be able to achieve maximal effect in reducing multiple types of violence by focusing on client violence. As a theoretical contribution, this finding complicates traditional syndemic models that frequently state that all factors are mutually causal. Our findings suggest that not all types of violence are equal in increasing risk for the other types of violence. It may be that only some types of violence (in this study, client violence) increase risk for other types of violence, or that the effect of some types of violence in potentiating risk is stronger than other types.

In Aim 2, the assessment of 4 major types of violence and 3 major sources of HIV risk enabled us to see that specific types of violence are implicated to different degrees in each of the major HIV risk pathways, supporting the need to distinguish specific types of violence from one another in designing interventions to promote health and safety for FSW. IPV was the only type of violence significantly associated with all 3 HIV risk pathways after adjusting for potential confounders. In contrast, client violence was only associated with injecting drug use. If multiple types of violence are more frequently included in HIV behavioral surveillance surveys, we can begin to build more nuanced understandings of the general statement “violence is associated with HIV risk” by looking at different types of violence and different sources of HIV risk in specific settings and populations. Results underscore the importance of assessing perpetrator type when assessing violence. Inconsistent and null findings in the literature examining the association between “violence” and “HIV” may be due to not looking comprehensively at

all types of violence or types of HIV risk. Only by looking comprehensively at all major forms of violence and HIV risk in a population does the full picture become clear.

IPV and police violence emerged as the most consistent predictors of all three forms of HIV risk in this population, affirming the importance of directly addressing these forms of violence in interventions aimed at reducing sexual or drug-related HIV risk in FSW. Police and intimate partner violence are infrequently targeted by interventions, perhaps due to persistent myths that FSW have clients but not intimate partners,[1] or concerns about tackling violence from state actors.

The linear dose-response analysis in Aim 3 highlights how attention to multiple, distinct types of violence is warranted. This analysis demonstrated that sexual and drug-related HIV risk increases significantly as the number of types of violence experienced increases. This finding emphasizes the importance of understanding and addressing polyvictimization, as reducing the number of types of violence experienced not only promotes sex workers' safety but also should reduce HIV risk.

We also propose new analytic tools for measuring synergism that enhance precision in evaluation of the “synergy” in “synergistic epidemics.” Using the quadratic dose-response, the multiplicative interaction, and the additive interaction analyses, we found no evidence of positive synergy. While there have been recent methodological papers calling for the use of interaction analyses to measure synergism in the syndemics field,[2] ours is the first empirical paper to our knowledge to implement and extend these proposed analyses, and the first paper in the quantitative syndemics literature that follows best practices for presenting additive and multiplicative interaction analyses. We also propose a new, simple analytic tool (the quadratic dose-response) that may have greater power in some datasets to detect potential synergism than multiplicative or additive interaction analyses, albeit with the drawback of losing specificity of information between particular pairwise violence interactions. Use of the methods we propose to quantitatively test for synergy will extend our understandings of the role synergism plays in syndemics and can guide context-specific development of interventions by understanding which syndemic factors interact synergistically to produce excess HIV risk. While standard linear dose-response

analyses are valuable in demonstrating the cumulative health burden from experiencing multiple syndemic factors, they are unable to assess synergy.

Rather than seeing positive synergism as predicted by syndemic theory, there were marginally significant negative interaction effects observed between IPV and client violence (ARR 0.87, $p=0.09$; RERI -0.15, $p=0.10$) and between IPV and police violence (ARR 0.86, $p=0.07$; RERI -0.17, $p=0.08$). This plateau effect may indicate that for highly polyvictimized individuals, more than one syndemic factor may have to be treated (or prevented) before any meaningful improvement in HIV risk is achieved, making it particularly important for intervention packages to target multiple syndemic factors simultaneously. The situation in which multi-component interventions are most critical to enact are situations in which syndemic factors are both mutually causal (which we demonstrated in Aim 1 by showing associations between violence types) and exhibit negative synergism, which would be consistent with the patterns observed in our dataset.

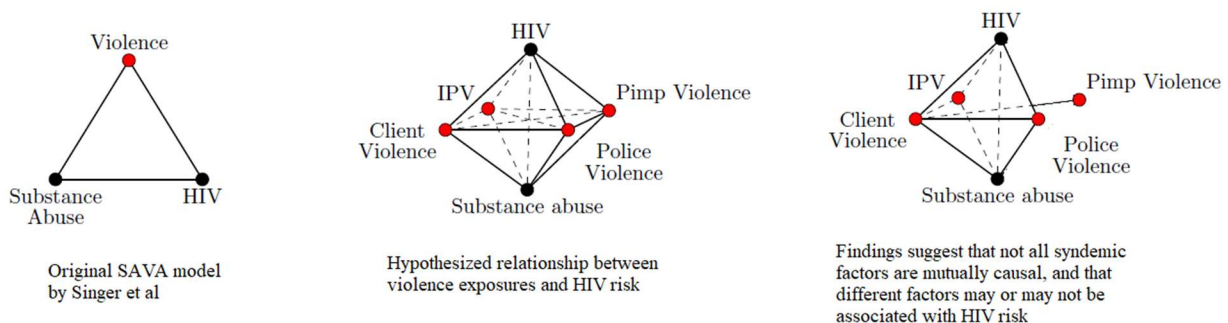
In contrast, single-component interventions may be quite effective in situations where there is evidence of positive synergy between syndemic factors. [3] If more syndemic analyses use the methods proposed in this dissertation to measure synergism, we can better understand the expected effect of single- and multi-component interventions in addressing specific syndemics. This is critical in resource-constrained settings where comprehensive multi-component interventions may or may not be feasible. If resources only permit for addressing a single syndemic factor, then the assessments used in this dissertation can enable identification of the syndemic factor that is most expected to benefit from a single-component intervention. This factor would be the factor that is most associated with the outcome of interest (as measured in Aim 2), while being less strongly associated with the other factors (weak mutual causality, as measured in Aim 1) and exhibiting positive synergism with other syndemic factors (as measured in Aim 3).

Our analytic proposals for quadratic dose-response, multiplicative interaction, and additive interaction may also yield dividends in the highly related polyvictimization literature. Just as in the

syndemics literature, linear dose-response obscures important differences between the different types of victimization ranging in seriousness from having parents divorce to being sexually abused.[4] While the language of “synergism” is less common in the polyvictimization literature, it is still the case that standard linear dose-response analyses do not provide new information if each exposure is already shown to be individually associated with the outcome.[2] Going beyond dose-response analyses to look at quadratic trends or interactions between specific types of violence may therefore open up new understandings in the field.

Extended understandings of syndemic violence and HIV risk in FSW

Figure 6.1: Evolving understandings of violence and HIV risk in FSW over the course of the dissertation



The analyses carried out in this dissertation enabled us to add considerable nuance to our understanding of the relationship between violence exposure and HIV risk in this population of FSW, as represented in Figure 2. On the left is the original SAVA model proposed by Singer et al 20 years ago,[5] showing that violence, substance use, and HIV are linked. At the beginning of the dissertation, we added complexity to this model by breaking apart violence into the four major forms of violence experienced by this population. While this octahedron is more complicated than the original triangle, it is straightforward in that every vertex is connected to every other vertex. Some, but not all, of the relationships we

hypothesized were supported by the data. In Aim 1, we discovered that IPV, pimp violence, and police violence may not all be strongly mutually causal with one another; in chapter 2, we found that pimp violence was not associated with our HIV risk outcomes. On the right, we have a more complex model where some links between vertices remain while others are removed as they are unsupported by the data. While this conceptual model defies pat description, it is more faithful to the data. Building models like this in different contexts and populations will help inform what forms of violence are most crucial to target when designing interventions for HIV and violence prevention. Our findings suggest that this violence syndemic as we have operationalized it in this sample of Russian FSW does not function as a syndemic in this population, at least in that it does not synergistically produce *excess* risk of HIV when multiple factors are experienced. According to a recent systematic review, this is the first quantitative application of the syndemics framework to look at more than two types of violence as syndemic factors.[3, 6]

Substance abuse, violence, and HIV – the components of the SAVA syndemic – remain vitally important issues for FSW, despite the lack of evidence in this analysis that violence types interact synergistically to produce excess HIV risk. As we found in the linear dose-response analysis, the cumulative effect of multiple types of violence on the health of sex workers is tremendous regardless of whether they interact synergistically. However, in cases where no synergism is observed, the amount of health burden is linearly proportional to the number of factors experienced and not in excess of that. . Qualitative work could continue to build out theory for whether there is a plausible basis for synergistic interaction between specific types of violence.

While our violence syndemic factors may not function synergistically, it is likely that many “syndemics” in the literature do not function synergistically, either, given that the majority of the quantitative literature on syndemics has not tested specifically for synergy.[3] Twenty years after the concept of syndemics was first laid out, the field stands at an exciting crossroads where the scope of social ills and conditions among a variety of marginalized populations under study is rapidly expanding

and the rigor of analytic tools in use is sharpening. The tools proposed and demonstrated in this dissertation can shine a clarifying light on the concept of synergism at the heart of syndemic theory. These tools may be useful as the field grapples with whether to move forward with a smaller subset of epidemics that exhibit synergism, or instead consider a broader set of mutually causal, potentially non-synergistic epidemics shaped by social inequalities. Regardless, syndemic theory remains a powerful framework for preventing and treating complex epidemics in marginalized populations.

Strengths and Limitations

A key strength of the dissertation is that it uses a dataset that comprehensively assess all major forms of violence and all major forms of HIV risk in this population. The sample size ($N=754$) is adequate for relatively complex analyses. These features allowed for implementation of novel analyses that have not previously been attempted in the literature.

More research is needed to address the limitations of this study. Longitudinal data would help establish temporality and narrow down potential causal mechanisms for the patterns observed in the study. Qualitative data would also help put results in context and suggest pathways by which each type of violence may potentiate risk for other types of violence. Because some violence profiles happen relatively infrequently, our sample size of 754 yielded small cell sizes for some violence combinations, causing some multivariate regressions (particularly interaction analyses) to be underpowered.

Measurement limitations include inconsistencies in how different types of violence were assessed in the survey, with client violence likely being the most sensitive measure; police were not assessed as potential physical violence perpetrators and intimate partners were not assessed as potential sexual violence perpetrators. Some of our results showing different implications of HIV risk for different types of violence may be due less to the fact that they were perpetrated by different perpetrators, and more related to the fact that they assess physical versus sexual violence. Other measurement issues include the common trajectory in many settings whereby clients may transition over time into intimate partner and/or

pimp roles.[7] For instance, some FSW may have experienced one incident of violence from a client-cum-intimate partner and based on this one incident reported having experienced both client violence and intimate partner violence. Further, police officers sometimes act as clients and purchase sex, which could cause conflation of client and police violence.[8] There were also some limitations to our assessment of HIV risk outcomes. For instance, the survey item for inconsistent condom use with an intimate partner assumed the respondent has a single intimate partner, though women may have multiple partners. Because of the aforementioned transition from client to intimate partner, there may have also been conflation of our two sexual risk outcomes, inconsistent condom use with clients and inconsistent condom use with intimate partners.

While we chose to look at the impact of lifetime violence on recent HIV risk, future work could look at the impact of recent violence on recent HIV risk as well. We chose to use lifetime exposures rather than recent exposures to violence as we conceptualized multiple forms of violence accumulating over the life course, placing an increasing cumulative burden on FSWs' health. However, it is possible that some of the null associations found in Chapter 4 between experiencing specific types of violence and specific HIV risk pathways might be due to *lifetime* violence having a weak effect on a recent outcome but *recent* violence having a stronger effect. This would be the case if the effect of violence on HIV risk is localized to the time period during which the violence is ongoing (e.g. risk behaviors are a direct and immediate response to the violence), rather than having a durable effect on behavioral patterns. Similarly, it is possible that there would be a stronger synergistic effect between specific types of violence observed when examining *recent* violence that temporally co-occurs within the same period, which would explain our null findings regarding synergy. While syndemic theory as it was laid out does not explicitly require exposures to be recent or co-occurring, one might hypothesize stronger synergistic effects with temporal overlap between exposures. For instance, a sex worker may feel able to cope with a single form of violence, e.g. ongoing client violence, if this type of violence is occurring in isolation. However, if she is also facing intimate partner violence, experiencing multiple violence exposures simultaneously may promote drug use as a coping mechanism to an overwhelming situation. In this scenario, co-occurring

IPV would synergistically increase the impact of client violence on HIV risk and vice versa. However, past IPV violence that has ended would not necessarily strengthen the link between client violence and HIV risk to the same degree. Information on frequency and intensity of each of the violence exposures would also help contextualize the null findings on synergy. It is possible that more severe or frequent exposures would interact synergistically in a way that infrequent or less severe exposures do not.

Conclusion

SAVA and polyvictimization analyses have persisted in the literature over the last two to three decades due to the compelling demonstration of the cumulative burden to health posed by accumulating victimizations and injustices. Despite this, we build on recent critiques calling for more complex analyses that better operationalize theoretical language by developing and demonstrating a new analytic toolset for analyzing syndemics. Findings also support the need for comprehensive interventions that consider multiple, specific types of violence in preventing sexual and drug-related HIV risk among FSW. The findings not only shed light on the specificities of Russian FSWs' HIV risk but also chart a new path forward for understanding intersecting epidemics in marginalized populations.

References

1. Strathdee SA, Crago A-L, Butler J, Bekker L-G, Beyrer C. Dispelling myths about sex workers and HIV. *The Lancet*. 2015;385(9962):4-7.
2. Tsai AC, Venkataramani AS. Syndemics and health disparities: a methodological note. *AIDS and Behavior*. 2016;20(2):423-30.
3. Tsai AC, Mendenhall E, Trostle JA, Kawachi I. Co-occurring epidemics, syndemics, and population health. *The Lancet*. 2017;389(10072):978-82.
4. Finkelhor D, Shattuck A, Turner H, Hamby S. Improving the adverse childhood experiences study scale. *JAMA pediatrics*. 2013;167(1):70-5.
5. Singer M. A dose of drugs, a touch of violence, a case of AIDS: conceptualizing the SAVA syndemic. *Free Inquiry in Creative Sociology*. 1996;24(2):99-110.
6. Tsai AC, Burns BF. Syndemics of psychosocial problems and HIV risk: a systematic review of empirical tests of the disease interaction concept. *Social Science & Medicine*. 2015;139:26-35.

7. Karandikar S, Próspero M. From Client to Pimp Male Violence Against Female Sex Workers. *Journal of interpersonal violence*. 2010;25(2):257-73.
8. Sherman SG, Footer K, Illangasekare S, Clark E, Pearson E, Decker MR. "What makes you think you have special privileges because you are a police officer?" A qualitative exploration of police's role in the risk environment of female sex workers. *AIDS care*. 2015;27(4):473-80.

Curriculum Vitae

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Profile	Ph.D.candidate and mixed-methods researcher in public health with a strong domestic and international research background. Research focus on gender-based violence, HIV/STI, and LGBT health. Proficient in French (DELF B2 certified).		
Education	Johns Hopkins School of Public Health	<i>Aug. 2013 – Sept. 2017</i>	<i>Ph.D., Department of Population, Family and Reproductive Health</i>
	Johns Hopkins School of Public Health	<i>Aug. 2010 – March 2012</i>	<i>Master of Science in Public Health, Global Disease Epidemiology and Control Department of International Health</i>
	University of Maryland, College Park, MD	<i>Sept. 2006 – May 2010</i>	<i>Bachelor of Science, Cell Biology and Molecular Genetics (summa cum laude) Bachelor of Arts, Piano Performance (summa cum laude) Minor, French Studies</i>
Research Positions	Johns Hopkins Departments of Epidemiology and Population, Family, and Reproductive Health, Baltimore, MD		
	<i>Research Assistant</i>	<i>Mar. 2015 – present</i>	Conducted participant observation/ethnographic fieldwork with Baltimore police Recruited, surveyed, and interviewed Baltimore drug-using sex workers
	Fenway Health, Boston, MA		
	<i>Clinical Data Specialist and Consulting Co-Investigator</i>	<i>Dec. 2012 – present</i>	Studied cervical cancer screening among sexual and gender minorities
	Johns Hopkins Department of International Health,	Baltimore, MD	
	<i>Research and Field Coordinator</i>	<i>July 2011 – Dec. 2012</i>	Designed mixed-methods study of Mongolian sex worker HIV risk and violence Assessed HIV and human rights issues in Gambian sex workers and MSM Conducted survey implementation, field staff training, and data management 8 months of international experience in Gambia, Senegal, and Mongolia
Journal Publications	<ol style="list-style-type: none">1. Peitzmeier, S., Agénor, M., Bernstein, I., McDowell, M., Alizaga, N.M., Reisner, S.L., Pardee, D.J., Potter, J.E. (2017). “It can promote an existential crisis”: Factors influencing Pap test acceptability and utilization among transmasculine individuals. <i>Qualitative Health Research</i>. In press.2. Decker, M., Tomko, C., Wingo, E., Sawyer, A., Peitzmeier, S., Glass, N., Sherman, S. (2017). A brief, trauma-informed intervention increases safety behavior and reduces HIV risk among drug-involved women who trade sex. <i>BMC Public Health</i>. In press.3. Reisner, S.L., Deutsch, M., Peitzmeier, S., White Hughto, J.M., Cavanaugh, T.,		

4. Valentine, S., **Peitzmeier, S.**, King, D., O’Cleirigh, C., Marquez, S., Presley, C., Potter, J. (2017). Disparities in exposure to intimate partner violence among transgender / gender nonconforming and sexual minority primary care patients. *LGBT Health*. In press.
5. McDowell, M., Pardee, D.J., **Peitzmeier, S.**, Reisner, S.L., Agénor, M., Alizaga, N., Bernstein, I., Potter, J. (2017). Cervical cancer screening preferences among female-to-male transgender individuals: Patient-collected human papillomavirus vaginal swabs versus provider-administered Pap tests. *LGBT Health*. In press.
6. Reisner, S.L., Randazzo, R.K., White Hughto, J.M., **Peitzmeier, S.**, DuBois, Z., Pardee, D.J., Marrow, E., McLean, S., Potter, J. (2017). Sensitive health topics with underserved patient populations: Methodological considerations for online focus group discussions. *Qualitative Health Research*. In press.
7. **Peitzmeier, S.**, Tomko, C., Wingo, E., Sawyer, A., Sherman, S., Glass, N., Beyrer, C., Decker, M. (2017). Acceptability of vaginal rings and pre-exposure prophylaxis for HIV prevention among female sex workers in a high-prevalence US city. *AIDS Care*. In press.
8. **Peitzmeier, S.**, Kågesten, A., Acharya, R., Cheng, Y., Delany-Moretlwe, S., Olumide, A., Blum, R., Sonenstein, F., Decker, M. (2016). Intimate partner violence perpetration among adolescent males in disadvantaged neighborhoods globally. *Journal of Adolescent Health* 59 (6): 696–702.
9. **Peitzmeier, S.**, Gardner, I., Weinand, J., Corbet, A., Acevedo, K. (2016). Health impact of chest binding among transgender adults: a community-engaged, cross-sectional study. *Culture, Health and Sexuality* 19 (1), 64–75.
10. Agénor, M., **Peitzmeier, S.**, Bernstein, I., McDowell, M., Alizaga, N., Reisner, S., Pardee, D., Potter, J. (2016). Perceptions of cervical cancer risk and screening among transmasculine individuals: patient and provider perspectives. *Culture, Health and Sexuality*. Epub ahead of print.
11. **Peitzmeier, S.**, Stephenson, R., Delegchoimbol, A., Dorjgotov, M., Baral, S. (2016). Perceptions of Sexual Violence among Men who have Sex with Men and Individuals on the Transfeminine Spectrum in Mongolia. *Global Public Health*. Epub ahead of print.
12. Agénor, M., **Peitzmeier, S.**, Gordon, A., Charlton, B., Haneuse, S., Potter, J., Austin, S. (2016). Sexual orientation identity disparities in human papillomavirus vaccination initiation and completion among young adult U.S. women and men. *Cancer Causes and Control* 27 (10): 1187–1196.
13. **Peitzmeier, S.**, Khullar, K., Potter, J. (2016). Effectiveness of four outreach modalities to patients overdue for cervical cancer screening in the primary care setting: A randomized trial. *Cancer Causes and Control* 27 (9): 1081–1091.
14. Agénor, M., McCauley, H., **Peitzmeier, S.**, Gordon, A., Haneuse, S., Potter, J., Austin, S. (2016). Sex of sexual partners and human papillomavirus vaccination among girls and women. *American Journal of Preventive Medicine* 50 (3): 318–327.
15. Potter, J., **Peitzmeier, S.**, Bernstein, I., Reisner, S.L., Alizaga, N., Agénor, M., Pardee, D. (2016). Cervical Cancer Screening for Patients on the Female-to-Male Spectrum: A Narrative Review and Guide for Clinicians. *Journal of General Internal Medicine* 30 (12): 1857–1864.
16. Grosso, A., Lei, E., Ketende, S., **Peitzmeier, S.**, Mason, K., Ceesay, N., Diouf, D., Dramé, F., Loum, J., Papworth, E., Baral, S. (2015). Condom Negotiation Difficulty and Condom Use among Female Sex Workers in The Gambia: Results of a Cross-Sectional Survey. *PeerJ* 3: e1076.
17. **Peitzmeier, S.**, Yasin, F., Stephenson, R., Wirtz, A., Delegchoimbol, A., Dor-

- jgotov, M., Baral, S. (2015). Sexual Violence against Men Who Have Sex with Men and Transgender Women in Mongolia: A Mixed-Methods Study of Scope and Consequences. *PLoS ONE* 10 (10): e0139320.
18. Agénor, M., **Peitzmeier, S.**, Gordon, A., Haneuse, S., Potter, J., Austin, B. (2015). Sexual orientation identity disparities in human papillomavirus vaccine knowledge and initiation in a national probability sample of young U.S. women. *Annals of Internal Medicine* 163 (2): 99–106.
 19. Sherwood, J., Grosso, A., Decker, M., **Peitzmeier, S.**, Papworth, E., Diouf, D., Dramé, F., Ceesay, N., Baral, S. (2015). Sexual Violence against Female Sex Workers in The Gambia: A cross-sectional examination of the associations between victimization and reproductive, sexual and mental health. *BMC Public Health* 15 (1): 270.
 20. Mason, K., Ketende, S., **Peitzmeier, S.**, Ceesay, N., Logie, C., Diouf, D., Loum, J., Deen, D., Dramé, F., Baral, S. (2015). Stigma, Human Rights Violations, Health Care Access, and Disclosure of Sexual Orientation Among Men Who Have Sex With Men in the Gambia. *Journal of Human Rights Practice* 7 (1): 139–152.
 21. **Peitzmeier, S.**, Bowes, A., Grosso, A., Ceesay, N., Baral, S. (2015). Associations of Stigma With Negative Health Outcomes for People Living With HIV in the Gambia: Implications for Key Populations. *JAIDS* 68, S146–S153.
 22. Lim, S., **Peitzmeier, S.**, Cange, C., Papworth, E., Lebreton, M., Tamoufe, U., Kamla, A., Billong, S., Fokam, P., Njindam, I., Decker, M., Sherman, S., Baral, S. (2015). Violence against female sex workers in Cameroon: Accounts of violence, harm reduction, and potential solutions. *JAIDS* 68, S241–S247.
 23. Decker, M., **Peitzmeier, S.**, Sangowawa, A., Acharya, R., Ojengbede, O., Covarrubias, L., Gao, E., Cheng, Y., Delany-Moretlwe, S., and Brahmabhatt, H. (2014). Prevalence and health impact of intimate partner violence and non-partner sexual violence among female adolescents aged 15–19 years in vulnerable urban environments: A multi-country study. *Journal of Adolescent Health* 55 (6): S58–S67.
 24. **Peitzmeier, S.**, Khullar, K., Reisner, S., Potter, J. (2014). Lower Pap Test Utilization among Female-to-Male Transgender Patients Compared to Non-Transgender Female Patients. *American Journal of Preventive Medicine* 47 (6): 808–812.
 25. Khullar, K., **Peitzmeier, S.**, Koffman, R., Potter, J. (2014). Impact of Electronic Documentation on Pap Screening Rates in an Urban Health Center. *Journal of Community Health* 39 (3): 416–22.
 26. **Peitzmeier, S.**, Reisner, S., Harigopal, P., Potter, J. (2014). Female-to-male transgender patients have high rates of unsatisfactory Paps compared to non-transgender females: Implications for cervical cancer screening. *Journal of General Internal Medicine* 29 (5): 778–84.
 27. **Peitzmeier, S.**, Mason, K., Ceesay, N., Diouf, D., Dramé, F., Loum, J., Baral, S. (2013). A cross-sectional evaluation of the prevalence and associations of HIV among FSW in the Gambia. *Int. J STD & AIDS* 25 (4): 244–52.
 28. Mason, K., Ketende, S., **Peitzmeier, S.**, Ceesay, N., Diouf, D., Loum, J., Deen, D., Dramé, F., Baral, S. (2013). A cross-sectional analysis of population demographics, HIV knowledge and risk behaviors, and prevalence and associations of HIV among MSM in the Gambia. *AIDS Res. and Human Retroviruses* 29 (12): 1547–52.
 29. Dramé, F., **Peitzmeier, S.**, Lopes, M., Ndaw, M., Sow, A., Diouf, D., Baral, S. (2013). Gay men and other men who have sex with men in West Africa: Evidence from the field. *Culture, Health & Sexuality* 15 (Suppl 1): 7–21.

Book Chapters	Peitzmeier, S., Potter, J. (2017). Patients and their bodies: The physical exam. In J. Potter & K. Eckstrand (Eds.), <i>Trauma, Resilience, and Health Promotion for LGBT Patients: What Every Healthcare Provider Should Know</i> , Springer, New York, 191–202.
Articles Under Review	<p>Jarrett, B.A. (mentee), Corbet, A.L., Gardner, I.H., Weinand, J.D., Peitzmeier, S. Care seeking behavior for chest binding-related health outcomes among transgender and gender non-conforming adults. Under review.</p> <p>Agénor, M., Batson, A., Peitzmeier, S., Borrero, S. Racial/ethnic disparities in human papillomavirus vaccination among young adult US women: The role of socioeconomic and health care factors. Under review.</p>
Conference Posters and Presentations	<p>Perpetration of partner violence among adolescent males in four global cities: Prevalence and correlates (Poster) Sexual Violence Research Institute Forum, Stellenbosch, South Africa <i>Sept. 2015</i></p> <p>Intimate partner violence perpetration among 15 to 19 year old males: Findings from a cross-national study (Poster) National Conference on Health and Domestic Violence, Washington, DC <i>Mar. 2015</i></p> <p>If You Have It, Check It: Overcoming Barriers to Cervical Cancer Screening with Patients on the Female-to-Male Transgender Spectrum 32nd Gay and Lesbian Medical Association Conference, Baltimore, MD <i>Sept. 2014</i></p> <p>Strengths and challenges of using electronic medical records to identify patients overdue for cervical cancer screening (Poster) 141st APHA Annual Meeting, Boston, MA <i>Nov. 2013</i></p> <p>Stigma and Discrimination Experienced by PLHIV in the Gambia (Poster) XIX International AIDS Conference, Washington, D.C. <i>July 2012</i></p>
Research Support (Under Review)	<p>NCI R01 HD092981-01 (Deutsch) <i>Clinical tools for high-risk HPV and cervical cancer screening in hard-to-reach gender and sexual minority populations (CaTCHing-GSM)</i></p> <p>The goal of this 5-year R01 is to improve rates of cervical cancer screening in trans men and cisgender sexual minority women by offering self-collection for high risk-HPV testing, within the context of a patient-provider shared decision-making tool that harnesses information on personalized HPV risk based on sexual behaviors. Role: Co-investigator</p>
Research support (current)	<p>NIDA F31 DA040558 (Peitzmeier) <i>Mar. 2016 – present</i></p> <p><i>HIV Risk, Substance Use, and Polyvictimization Among High-Risk Women</i> Dissertation work exploring how different types of violence (from clients, police, intimate partners, and pimps) differentially affect sexual and drug-related HIV risk among female sex workers in Russia, and how polyvictimization with multiple forms of violence synergistically propagates HIV risk. Role: PI</p>

Research Support (Completed)	<p>PCORI CER-1403-12625 (Reisner) <i>Oct. 2014 – Jan 2017</i> <i>Preventive sexual health screening among female-to-male (FTM) transgender adult patients</i> Two-year, \$813,000 study assessing acceptability and effectiveness of alternative sexual health screening modalities in transgender men. Role: Co-investigator</p> <p>NICHD T32 HDO64428 (Campbell) <i>Aug. 2013 – Aug. 2015</i> <i>Interdisciplinary Training on Preventing and Addressing Violence in Families</i> Pre-doctoral traineeship</p> <p>Johns Hopkins Center for Public Health and Human Rights <i>Jan. 2012</i> <i>Student Research Grant</i> \$5,000 research grant supporting work I proposed and conducted in Mongolia</p> <p>HHMI Research Fellowship <i>May 2008 – May 2010</i> Laboratory research at the University of Maryland and University of Glasgow on B- and T-cell responses in multiple sclerosis patients</p>
	<p>Awards</p> <p>Dr. Michael Koenig Memorial Fund awards, for \$6,500 and \$10,000 of tuition support (Apr. 2015 and Apr. 2016)</p> <p>Student Scholarship to attend the National Science Foundation/National Institute of Justice Workshop on Intimate Partner Violence Prevention (Mar. 2014)</p> <p>Georgeda Buchbinder Award, awarded to two students annually for excellence in the Johns Hopkins International Health department (April 2011)</p> <p>University Medal, awarded to the top student in the University of Maryland graduating class of more than 5,000 students (May 2010)</p> <p>Rhodes (2009) and Marshall (2009, 2012) Scholarship Finalist</p> <p>Philip Merrill Presidential Scholar, awarded to the 25 most successful rising seniors at the University of Maryland (Mar. 2009)</p> <p>Barry M. Goldwater Scholarship, national recognition for excellence in scientific research (Mar. 2009)</p> <p>Banneker-Key Scholarship, 4-year full scholarship (Apr. 2006)</p>
	<p>Service Activities</p> <p>Johns Hopkins Sexual Violence Advisory Committee Aug. 2014 – present Advise the provost on improving sexual violence response across the university. Results include instituting evidence-based bystander intervention training for all incoming undergraduates and revamping official sexual assault policies.</p> <p>RAINN National Sexual Assault Online Hotline Volunteer <i>Aug. 2008 – present</i> Provide online crisis-intervention for victims of sexual assault.</p> <p>Needle Exchange Program Volunteer, Baltimore, MD <i>Oct. 2010 – May 2012</i> Surveyed and distributed harm-reduction packages to injecting drug users.</p> <p>Polaris Project Summer Fellow, Washington, D.C. <i>June – Aug. 2010</i> Staffed national hotline for victims of sex and labor trafficking.</p> <p>SARPP Peer Advocate, College Park, MD <i>Aug. 2009 – May 2010</i> Supported students at the University of Maryland affected by sexual assault.</p>

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	Professional Epidemiology Methods I (Johns Hopkins) <i>Spring 2012</i>
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