ORIGINAL ARTICLE

Estimating the Impact of Reducing Violence Against Female Sex Workers on HIV Epidemics in Kenya and Ukraine: A Policy Modeling Exercise

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Problem
Female sex workers (FSWs) worldwide suffer disproportionate burdens of HIV and gender-based violence. Despite evidence linking these threats, little is known about the potential HIV epidemic impact of reducing abuse.

Method of study
The Goals model approximated the impact of reducing violence against FSWs on HIV epidemics in Ukraine and Kenya, measured by reductions in new infections among FSWs and adults. Cumulative infections averted over a 5-year period, in which violence declined was calculated, relative to a status quo with no reduction. Projections held HIV interventions constant at baseline levels; subsequently, scenarios adjusted for planned expansion of antiretroviral therapy (ART) coverage.

Results
An approximate 25% reduction in incident HIV infections among FSWs was observed when physical or sexual violence was reduced; cumulative infections averted were 21,200 and 4700 in Kenya and Ukraine, respectively. Similar percent reductions were observed assuming ART coverage expansion, with approximately 18,200 and 4400 infections averted among FSWs in Kenya and Ukraine. New infections were also averted in the general population.

Conclusion
Reducing violence against FSWs appears to impart significant reductions in new infections among FSWs and in the general adult population in both generalized and concentrated epidemics. Limitations provide direction to improve the precision of future estimates.

Introduction

Many classes of models have been used to synthesize the scientific theories, hypotheses and data emphasized in this special issue. This article describes a different class of models: one that seeks to harness a rapidly emerging evidence base to inform policy and programmatic developments. We can think of a policy model as generating 'what-if' scenarios informed by the best available, albeit imperfect, data to inform

important policy questions.[1] Our policy model blends social epidemiology with infections disease modeling. It focuses on violence and HIV among female sex workers (FSWs), a scenario for which growing evidence links violence with HIV risk and infection, yet given the natural lag in the development and testing of related interventions, we have little intervention data to estimate the HIV epidemic impact achievable through reducing violence.

Briefly, it is well documented that FSWs worldwide suffer a disproportionate burden of HIV.[2] Thus, mitigating risks for acquisition and transmission among this group remains an international priority. More recently, a new and quickly growing empirical evidence base demonstrates that FSWs suffer alarming levels of physical and sexual violence perpetrated by clients, police, and other actors.[3–7] Consistent with evidence from the general population,[8–10] violence against FSWs is associated with increased risk of HIV infection,[11] as well as STI symptoms[12] and infections.[3,4,13] Evidence from the general population illustrates that violence cannot directly cause HIV; rather it influences risk through a complex set of proximal factors such as unprotected sex,[3,7,14–17] physiologic factors and genitoanal injury associated with sexual violence,[18–21] partners who may be at greater risk for infection,[22] and injection drug use.[11] While much of the evidence base specific to FSWs is cross-sectional, prospective research from non-FSW samples has found violence and gender inequality linked with incident STIs,[23] including HIV,[24] strongly suggesting a causal link. The high burden of violence against FSWs, coupled with its observed impact on HIV risk, illustrate an urgent need to address the violence-related HIV risks to FSWs.

Given these data, policy-makers have good reason to consider the potential HIV impact of reducing violence against FSWs, and the types of epidemic scenarios in which reducing violence would impart the greatest impact. A traditional modeling approach could answer this question by approximating the HIV impact of scaling up a given, evidence-based intervention. To date, the interventions that have recently emerged to reduce violence against FSWs[3,25] have yet to be evaluated for their impact on HIV as an outcome. However, the existing research does allow for an evidence-based conceptual framework for the links of violence with HIV among FSWs. These data can inform a hypothetical epidemiological modeling scenario that approximates the impact of reducing violence against FSWs. This approach, while compromised in precision by the limitations of the existing data, provides the rapid guidance necessary to respond quickly to this emerging issue and identifies the data gaps to be filled to support more robust estimates.

Hence, we begin to inform the extent to which violence prevention should be prioritized within global HIV prevention efforts for FSWs by estimating the number of new infections that could be averted both among FSWs and in the general population when violence against FSWs is reduced to a given level. In doing so, we identify the research gaps that must be filled to sharpen the precision of subsequent estimates.

Methods

The Goals HIV Impact Model

The Goals Model (Futures Institute, Glastonbury, CT, USA) is part of the Spectrum suite of policy tools. It is widely used to evaluate the impact and cost of scaling up behavioral interventions (e.g., community mobilization, voluntary counseling and testing) both individually and in combination, and new preventative technologies (e.g., male circumcision, treatment as prevention, vaccines) aimed at reducing HIV incidence. It contains a transmission model that calculates the number of new HIV infections among 15–49-year-old adults over time as a result of sexual and injecting drug transmission. The calculation uses epidemiological data, including transmission probabilities in different stages of disease, the presence of other STIs, the level of male circumcision and antiretroviral therapy (ART), and behavioral data, including the median age of sexual debut, number of sexual partners per year and condom use levels. These data are often available from DHS and behavioral surveys, as well as surveillance and other reports.[26]

Underlying Goals is DemProj (Demographic Projection model), which produces demographic projections based on data drawn from the United Nations Population Division's database. The data consist of historical sex and age distributions, which are projected forward based on trends in fertility, mortality, and migration. Adjacent to Goals is AIM (AIDS Impact Module), which uses national HIV treatment and PMCT program statistics to project the consequences of changes in incidence, including the number of people living with HIV, number of new HIV

infections, number of pregnant women infected with HIV, and mortality due to AIDS. AIM is used by UNAIDS to make the national, regional and global estimates of HIV burden, and to forecast national near-term treatment and PMTCT needs. Goals works in tandem with DemProj and AIM, specifically to ensure that its general population matches the 15–49-year-old from DemProj in all important respects, while its HIV-positive population matches the 15–49-year-old HIV-positive population from AIM.[26]

Young adults enter the Goals model at age 15 and at a rate consistent with the underlying demographic model. They are assumed to be sexually inactive until they reach the median age at first sex for a particular country. Individuals are then allocated to one of five risk categories which are epidemiologically relevant and for which information is available through national surveillance, specifically stable couples (men and women reporting a single partner in the last year), multiple partners (men and women who report more than one partner in the last year), female sex workers and clients, men who have sex with men (MSM) and people who inject drugs (IDU). The modeler then populates the specific behavioral and epidemiologic data parameters for each risk group for the projection. Individuals belonging to more than one category are allocated to the category of highest risk. They can transition to the next category of lower risk. For example, FSWs can transition to the medium-risk category in accordance with the average duration of sex work based on country data. Individuals mix with partners in their own risk category; in this context, sexual contact is between FSWs and high-risk men/clients. The average annual number of sexual partners is populated for each risk group, as is the percent married, allowing an estimation of the proportion of FSWs who are presumed to also have sex with low risk men;[26] beyond these parameters, the model does not currently have a means to explicitly handle concurrency.

Goals and AIM share the same CD4 structure and ART allocation mechanism to progress individuals who are HIV positive. Progression for those infected with HIV is handled with seven CD4 compartments, through which HIV+ individuals move at specified rates. Many HIV-related parameters of the progression model of Goals vary as a function of CD4 count: progression to lower CD4 counts, HIV-related mortality, probability of initiating ART and infectiousness. Depending on the eligibility criterion and the level of first line ART coverage, a percentage of those eligible for treatment will start first line ART. For this exercise, allocation of ART was assumed to occur at a CD4 < 350 cells/mm^{327}, and transmission is reduced by an estimated 0.13%.[28] Individuals already on ART are categorized by their CD4 count at the initiation of treatment. The model does not track the temporal increase of CD4 counts of those on treatment. The possible cessation of treatment is not explicitly modeled but is captured through maintaining an observed treatment volume.

Linking Violence 'Causally' to HIV in Goals

The causal pathways linking violence with HIV are multifaceted and complex;[29] for this exercise, we did not seek to consider the entire range of plausible pathways. We focused on unprotected sex as the most proximal sexual risk pathway, and one that is well-supported by qualitative[14,15,17,30] and quantitative evidence.[31] To parameterize the association between violence and HIV among FSWs, we used a recent systematic review recently commissioned by the WHO.[31] Across the articles identified that evaluated associations of violence with HIV risk behaviors, the most consistently assessed outcome was condom non-use, typically defined as any unprotected sex over a set period such as the past week or month; one manuscript specified pressured into unprotected sex.[32] While rarely specified, the unprotected sex was conservatively assumed to be vaginal. Of the six articles that estimated associations of violence with unprotected sex,[3,7,12,32–34] two were excluded based on insufficient information for risk ratio calculation (i.e., odds ratios were presented without the raw data or proportions necessary to calculate a risk ratio);[33,34] and an additional manuscript that provided the necessary parameter supplemented the remaining reports.[16] Associations of violence with condom non-use were meta-analyzed for this modeling exercise and a summary risk ratio generated for the association of violence with unprotected sex: RR 1.69 (CI: 1.27–2.25).

Given the transmission efficiency of anal intercourse,[35–37] we explored unprotected anal intercourse as a second risk pathway linking violence with HIV. A growing body of research demonstrates links between violence and anal intercourse, often unprotected, among FSWs.[4,15,17,38] Unfortunately, the necessary inputs were inconsistently presented across studies; some described violence as a primary

context for anal intercourse,[15,17] and others present associations of violence with anal intercourse without presenting data on condom use.[4,12,38] Only one study provided the necessary inputs for our current analysis: specifically, the data presented enabled calculation of associations of violence with unprotected anal sex. Findings affirm an association of violence with anal intercourse, and among those involved, no significant differences in condom use were identified; in other words, violence relates significantly to anal intercourse, some of which is unprotected.[3] These data provide the parameters with which to estimate the link of violence with unprotected anal intercourse, estimated at RR: 3.11.

Goals uses an 'impact matrix' to translate changes in exposure to an intervention to changes in sexual behavior, such as condom use;[26] typically Goals would estimate impact through increasing population coverage of a given intervention. In this exercise, we directly modeled a hypothetical decrease in the population prevalence of violence against FSWs, and estimated its impact on the reduction in transmission through a reduction in unprotected vaginal and anal sex. This is a two-step process involving the following equation for an average transmission probability among FSWs:

$$f = (1 - \mathrm{p})\mathrm{t} + \mathrm{mpt}$$

where f is a function of prevalence of anal sex (*P*), the assumed transmission probability per sex act (t) and the transmission multiplier for unprotected anal sex (m).

Step 1: To model the relative decrease (D) in unprotected anal sex in response to a decrease in sexual violence, we used:

$$\mathrm{D} = \mathrm{RR\ of\ violence\ induced\ AS} = 3.11 - 1 = 2.11$$

Step 2: To estimate the level of condom non-use associated with violence, we used the condom non-use among FSWs generally, adjusted by the relative risk of condom non-use based on violence exposure: RR = 1.69.

Table I depicts the modes of transmission, associated transmission efficiencies, and data sources used for this modeling exercise.

Table I Behavioral and Transmission Risks Related to Violence

Mode of transmission	Estimate	Method	References
Violence and unprotected vaginal sex	RR 1.69	Meta- analysis	3,7,12,16,32
Violence and anal sex	RR 3.11	Risk ratio calculation	3
Transmission probability ratio unprotected anal intercourse to unprotected vaginal intercourse	16	Published meta-analysis	35

Modeling Scenarios

We selected two disparate settings for this analysis: Kenya, one of Africa's generalized epidemics, and Ukraine, one of the concentrated and rapidly expanding epidemics of the Eastern Europe/Central Asia region. Both countries have significant FSW populations, against whom severe physical and sexual violence have been reported.

Goals model parameters were populated with behavioral and epidemiological data drawn from the most recent and highest quality surveillance reports, UNGASS or UNAIDS country reports, and published studies from Ukraine[39] and Kenya[40,41] (Table II). An initial model calibration fit the Goals HIV epidemic projections for each nation to the median adult population HIV prevalence estimates from UNAIDS,[40,42] within the 95% confidence intervals. FSW-specific HIV estimates were calibrated against published data from Kenya[43–48] and Ukraine[39] to confirm model fit.

Physical or sexual violence prevalence estimates were informed by peer-reviewed literature and surveillance reports. For Ukraine, a weighted prevalence of 39% was calculated, based on the only estimates available for Ukraine, which specified police as perpetrators, and client-perpetrated estimates from elsewhere in the region, given the small sample size for the only Ukraine data identified.[4,6] Kenya's baseline prevalence was 32% given recent evidence of this estimate for past year, client-perpetrated sexual violence among FSWs.[49] For both countries, we used a transmission multiplier of 16 for unprotected anal sex relative to vaginal sex,[35–37] and an anal intercourse prevalence of 12%.[3,4,12,38,50]

We projected the approximate number of new infections averted among FSWs and the adult population. We ran two sets of scenarios: the first

Table II Key Model Parameters and Data Sources

	Kenya			Ukraine		
Parameter	Model value	Range	Reference(s)	Model value	Range	Reference(s)
Baseline HIV prevalence: adults	6.0%	5.8–6.5%	40,41,64	1.1	95% confidence interval: 1.0–1.3%	42,65
Baseline HIV prevalence: FSWs	33.8%	3.4–66.8%	38,44–48,66,67	13.2%	0–39%	68
FSW population size	299,089	> 100,000	41, 69	88,081	65–95,000	68
Condom use among FSWs (vaginal intercourse)	60%	29–91%	70–73	70%	66–80%	42,74
Number of clients	105	100–156	70,71,75	210	50–1000	76
Proportion of FSWs who are married	5%	<1–23%	77	4.1%	5%	76
Prevalence of violence against FSWs	32.4%	32.4–35.0%	8,22	39.0%	30.0–85.0%	4,6
Pooled estimates: not specific to modeled countries						
Prevalence of anal sex among FSWs	12.0%	3.5–40.0%	3,4,12,38, 49,50,78	12.0%	3.5–40.0%	3,4,12,38, 49,50,78

reduced the prevalence of violence against FSWs from baseline over a 5-year period, all other interventions (including ART coverage, denoted ART-M) were maintained at the baseline level. For Kenya, we assessed scenarios in which violence was reduced from 32.40 to 18.40 and 2.40% over a 5-year period. Likewise, for Ukraine, violence against sex workers was reduced from 39.00 to 25.00 and 9.00% over the 5-year period (Scenarios 1 and 2, Table III).

Subsequently, we adjusted our analyses to account for a separate, yet significant, structural change, specifically the planned expansion of ART for those infected in the adult population as a means of both individual-level treatment as well as population prevention.[51] This second set replicated these same two scenarios for each country in the context of nationally planned ART expansion (denoted ART-E, Scenarios 3 and 4, Table III). In Kenya, national plans suggest ART coverage will expand from 63 to 85% by 2016. In Ukraine, ART coverage is lower at 12%, and expected to expand to 25% of those in need of ART by 2016. In the Goals model, ART expansion is equally distributed across all risk groups according to the proportion of people living with HIV and with a CD4 < 350 cells/mm^3 in each group. These scenarios were compared against status quo, in which there was no change in the prevalence of violence against FSWs. With these comparisons, annual new infections were transformed to infections averted and cumulative infections averted across the 5-year time span.

Results

Figure 1 depicts the impact of a reduction of violence against FSWs in Kenya from a baseline prevalence of 32.4 to 18.4% and to 2.4% by 2016, when

Table III Modeling Scenarios to Project Impact of Reduction of Violence with and Without National Expansion of ART

	Set 1: Maintained ART coverage (*ART-M*)			Set 2: Expanded ART coverage (*ART-E*)		
	Status quo (%)	Scenario 1 (%)	Scenario 2 (%)	Status quo (%)	Scenario 3 (%)	Scenario 4 (%)
Kenya						
Violence prevalence by 2016	32.40	18.40	2.40	32.40	18.40	2.40
ART coverage (%) by 2016	63.00	63.00	63.00	85.00	85.00	85.00
Ukraine						
Violence prevalence by 2016	39.00	25.00	9.00	39.00	25.00	9.00
ART coverage (%) by 2016	12.00	12.00	12.00	24.00	24.00	24.00

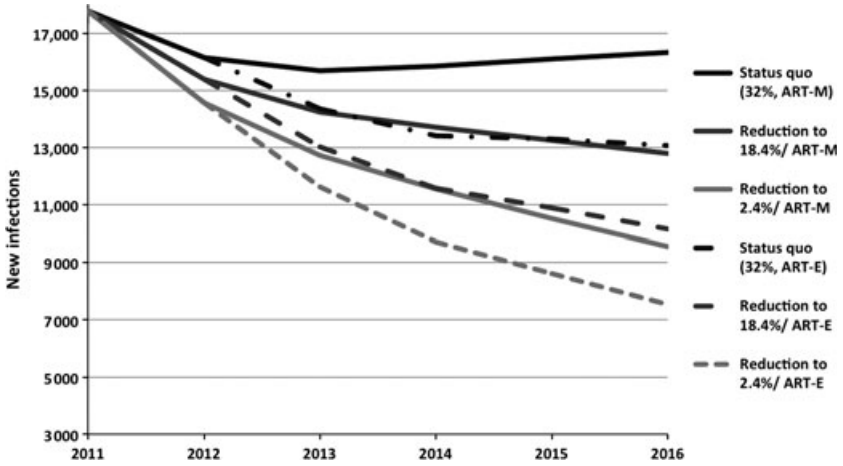

Fig. 1 Trends in new infections among female sex workers in Kenya based on violence prevalence and maintained versus expanded ART coverage (2011–2016). Violence Prevalence (%) /ART coverage maintained (M) versus expanded (E). Note Y axis begins at 3,000 new infections.

all interventions and ART are maintained at a baseline level (ART-M). Reducing violence against FSWs to 2.4% by 2016 results in a cumulative 21,200 infections averted among FSWs over this time period, or a 27% reduction. Among the general adult population, an estimated 53,200 infections are averted (translating to reductions of 12% in new infections) when violence against FSWs is reduced to 2.4%.

Combined with ART expansion (ART-E), reducing the prevalence of violence to 2.4% by 2016 results in 18,200 infections averted among FSWs (26% reduction) in Kenya. Among adults, more than 45,400 new infections may be averted (6% reduction), when violence is reduced and ART simultaneously expanded over this 5-year time period.

Figure 2 depicts similar patterns of incidence reduction in Ukraine. Assuming maintained ART coverage (ART-M), reducing violence from 39 to 9% by 2016 results in an estimated total reduction in new infections among FSWs of 25%, or a cumulative 4700 new infections averted, relative to the status quo. Among adults, reducing violence against FSWs to 9% results in an estimated 25,900 infections averted (10% reduction), respectively, compared with status quo.

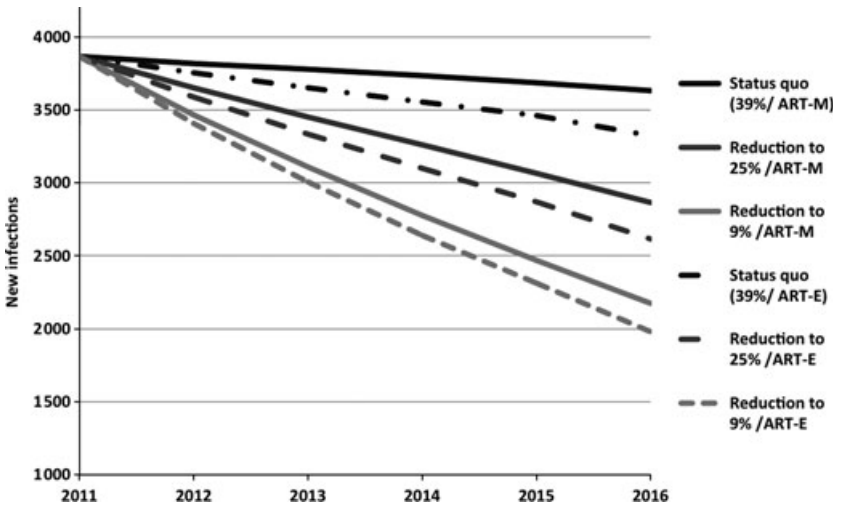

Fig. 2 Trends in new HIV infections among female sex workers in Ukraine based on violence prevalence and maintained versus expanded ART coverage (2011–2016). Violence Prevalence (%) /ART coverage maintained (M) versus expanded (E). Note Y axis begins at 1,000 new infections.

Assuming expanded ART coverage (ART-E) in Ukraine, similar impacts in new infections are observed among FSWs and adults with reduced violence against sex workers. Reducing the prevalence of violence to 9% by 2016, as ART expands, results in a 25% reduction in new infections, or 4400 infections averted among FSWs. In the general adult population, reducing violence against FSWs to 9% results in an estimated 24,600 cumulative infections averted (6% reduction), respectively, between 2012 and 2016.

Discussion

Our policy modeling exercise suggests that reducing violence against FSWs can have a significant impact in reducing HIV among FSWs and adults in both generalized and concentrated epidemics. Even when ART coverage is expanded, demonstrable impacts are observed, reaching 25–26% and 6% reductions in new infections among FSWs and adults, respectively. The precision of these estimates is subject to limitations of the available data.

By providing a range of plausible impacts on the HIV epidemics that could be achieved by reducing physical and sexual client-perpetrated violence against FSWs, this exercise supports the relevance of investing in developing and testing violence-reducing interventions for the FSW population. Recent evidence demonstrates the capacity of both community-based and individual-level interventions to reduce violence against FSWs.[3,25] Further research is needed to understand the HIV risk and infection implications of such interventions, and to understand their impact in a broader range of settings. Moreover, empowerment-based HIV prevention efforts for sex workers may serve as a useful infrastructure with which to implement anti-violence campaigns, as is suggested by recent findings from India.[52] At the individual level, FSWs should be supported to discuss their experiences of violence in a safe space with trained counselors familiar with the multiple layers of trauma that FSWs so often experience. Structural interventions are also necessary to modify the climates that enable abuse. Because the context of criminalization of sex work enables police and clients to perpetrate violence with impunity,[53] decriminalization efforts should be explored for their potential to reduce violence. So too, police sensitization training may be a critical step in reducing harassment of FSWs as well as removing the demonstrated barriers to obtaining justice faced by FSWs who have experienced violence.[54] In addition to efforts to mitigate the immediate consequences of violence for those affected, interventions are urgently needed to modify both the abusive behavior of male perpetrators, and the climate of impunity that enables such abuse.

A research agenda for improving the precision of future similar modeling exercises is informed by our study limitations. A central issue relates to the clarification of causal pathways. Longitudinal research that includes serostatus assessment is necessary to refine our understanding of the mechanisms linking violence to HIV among FSWs, and among broader populations. The mediating pathways proposed must be further tested, and additional mediating pathways explored. Inclusion of biological outcomes for HIV and other STIs in violence-related basic research, as well as prevention and intervention research will also provide necessary inputs for future modeling. HIV risk behaviors and infection in FSWs' sexual networks, particularly male violence perpetrators, requires attention as a possible explanatory mechanism, as men who perpetrate physical and sexual violence have been found to demonstrate greater sexual risk behavior[22,55–59] and are more likely to be STI/HIV infected,[22,56,59,60] rendering violence a risk marker for sex with a high-risk partner.[22] Surprisingly, there was a lack of clarity in the type of unprotected sex assessed in many studies, which limited the precision of estimates related to both vaginal and anal unprotected sex. In particular, data on unprotected anal intercourse as it relates to violence were limited and inconsistently collected, with only one study available to inform model parameters specific to violence and unprotected anal intercourse, limiting the precision of our estimates. As evidence increasingly demonstrates that women engage in anal sex, including that which is unprotected, coupled with the transmission efficiency of unprotected anal intercourse,[35,36] HIV-related research with women must specify vaginal vs. anal in condom use assessments.

Another central limitation to the precision of our estimates is the inconsistency in violence assessment in research with FSWs. Future modeling and intervention research will benefit tremendously from standardized assessments for FSWs' experiences of both physical and sexual violence that specify the nature of sexual violence (i.e., vaginal or anal, and coerced vs. forced), and the perpetrator relationship

(e.g., client, police, other). Physical and sexual violence may influence HIV risk differently; while both may be enacted to demonstrate power and can prompt condom non-use, sexual violence can additionally heighten risk for HIV transmission via physical trauma resulting from forced or unwanted sex,[61,62] and anal sex confers unique risk for HIV transmission. Specifying the perpetrator (e.g., clients, police, partners) is critical because the HIV impact of violence against FSWs can vary based on perpetrator.[4] For example, client abuse and police sexual abuse, have been directly associated with HIV/STI, whereas abuse from pimps appear to influence risk indirectly by prompting women to take on additional clients.[4] Policing can also influence risk indirectly, for example, when FSWs work in remote areas to avoid police they can be subject to HIV risk.[32] Standardized measures and protocol guidelines for sampling, ethical protections, training of research staff, and quality assurance measures are necessary to support the high-quality violence-related research for FSWs that is now standard within the general population.[63] Finally, our modeling approach required inputs in the form of risk ratios or prevalence ratios, yet most epidemiological research still presents odds ratios or adjusted odds ratios. While much of the literature provided sufficient information to calculate risk ratios directly, this approach renders estimates subject to potential confounding. In our case, all of the estimates that informed the risk ratio calculation had adjusted odds ratios that were significant at $P < 0.05$, with one exception that was presented as an adjusted risk ratio and thus included.[4] Thus, while the precision of our risk ratio estimates is compromised, the overall relevance of the risk pathways is less so. Future research that presents adjusted risk ratios will enable more precise modeling.

As our understanding of the impact of violence on HIV evolves, and as we strive for high-quality data from a diversity of settings, a policy model such as the exercise presented here holds practical utility. The burden of physical and sexual violence against FSWs perpetrated by clients, police and other actors strongly indicates the need for intervention to protect the safety and well-being of this population. Current findings suggest that reducing client-perpetrated physical and sexual violence may offer benefits to both FSWs and broader adult populations in terms of reducing the burden of HIV. Findings confirm the relevance of violence prevention for FSWs globally, and provide direction for a research agenda to advance the precision of subsequent modeling on this topic.

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Disclosures

The author has no potential conflicts of interest to declare.

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