

Table 1: Frameworks for characterizing the role of sex work¹ in HIV epidemics, and the implications for HIV programmes.

	Definition	Assumption	Pros	Cons	Implications for designing HIV programmes
Generalized HIV epidemic (Numerical Proxy)	Region where HIV prevalence is currently >1% in the general population (usually measured via ante-natal clinic surveillance) [18]	Sex work is less important than other sexual partnerships to HIV spread	Easy to classify (little data needed)	Does not reflect underlying transmission dynamics and role of key populations in HIV spread	Leads to broad recommendation that HIV prevention is applied to “all segments of society” (no specific focus)
Short-term distribution of newly acquired HIV infections (Modes of Transmission model)	Fraction of new HIV infections acquired across risk-groups (such as FSWs, clients) in one year	No onward transmission chains No overlapping risk-factors	Easy to use with empiric prevalence and size of FSW/client population	Underestimates the transmission PAF in the medium to long-term Cannot disentangle multiple risk-factors (example, sex work and sharing needles) in same subgroup	Could lead us to underestimate the importance of focused HIV programmes for FSWs/clients
Classical PAF	Fraction of prevalent or incident HIV infections that occur in FSWs (or clients) relative to non-FSWs and non-clients	No onward transmission chains	Easy to calculate using empiric HIV prevalence or incidence data and size of FSW/client population	Underestimates the transmission PAF in the medium to long-term Cannot disentangle multiple risk-factors (example, sex work and sharing needles) in same subgroup	Could lead us to underestimate the importance of focused HIV programmes for FSWs/clients
Transmission PAF (T-PAF)	Fraction of cumulative new HIV infections that are due (directly and indirectly) to unprotected sex work	Onward transmission chains We know, or can triangulate or vary, the sexual mixing between risk-groups. Patterns of sexual mixing or size of the sex work population are assumed to remain stable or resemble temporal changes observed in the past only, over the time-frame of the T-PAF estimate.	Accounts for indirect transmission chains; can disentangle multiple risk-factors	Requires dynamic mathematical models to estimate Dependent on the empiric data inputs (including sexual mixing between risk-groups, and sex work definition (thus, population size of FSWs/clients) Can depend on the subgroup-specific data the model is calibrated to [measured HIV prevalence, incidence, HIV sequencing] Will depend on the structure of the model and level of heterogeneity in sexual behaviour	Can be interpreted as the largest potential fraction of new HIV infections that could be averted with ideal interventions that protected all FSWs/clients from HIV.

“Generalized” HIV epidemic based on underlying transmission dynamics	Region where sex work (or other well-defined high-risk behaviours such as injecting drug use, etc ¹) is neither sufficient nor necessary to enable HIV to establish and spread (for R_0 to exceed 1)	Sex work (or other well-defined high-risk behaviours) are not important to sustain HIV spread	Accounts for indirect transmission chains; can disentangle multiple risk-factors	To date, requires dynamic mathematical models to classify Dependent on same data as with the transmission PAF	Local HIV epidemic could be controlled without sex work interventions
“Mixed” HIV epidemic based on underlying transmission dynamics	Requires either commercial sex or other partnerships (for example, casual sex or multiple partnerships) for HIV to establish and persist, such that both commercial and casual sex acts would need to be protected to achieve long-term elimination ($R_0 < 1$).	Sex work (or other well-defined high-risk behaviours) can sustain HIV spread, but preventing transmission within commercial sex alone would not be enough to control the local HIV epidemic	Accounts for indirect transmission chains; can disentangle multiple risk-factors	To date, requires dynamic mathematical models to classify Dependent on same data as with the transmission PAF Does not specify the contribution of sex work (or other well-defined risk-groups) versus other partnerships to overall HIV spread	Local HIV epidemic control requires interventions focused on sex work and on other risk-behaviors in the general population
“Concentrated” HIV epidemic based on underlying transmission dynamics	Requires that commercial sex exist for HIV to establish and persist in the population, (R_0 is greater than 1 in the presence of commercial sex, and < 1 in the absence of commercial sex)	Sex work (or other well-defined high-risk behaviours) can sustain HIV spread	Accounts for indirect transmission chains; can disentangle multiple risk-factors	To date, requires dynamic mathematical models to classify Dependent on same data as with the transmission PAF	Local HIV epidemic could be controlled with sex work interventions

R_0 (basic reproductive ratio: the average number of new infections due to one infectious case in an otherwise susceptible population)

¹The focus of this paper is on sex work; but behaviours could include those relevant within other key populations (for example, injecting drug use)

Table 2. Estimates of the contribution of sex work to generalized HIV epidemics in SSA.

System	Approach	Number of generalized HIV epidemics in SSA ² with recent data, of 39 countries (years)	Estimate	Median % (range)	Concerns/Issues	Sources
Routine surveillance	HIV Modes of Transmission Model	18	% of new HIV infections acquired by FSWs and clients, over 1 year	FSWs: 2.0 (0.1,13.7) Clients: 7.0 (0.46,25.6)	Underestimates the transmission PAF in the medium to long-term[29]	UNAIDS Reports 2014 Systematic Review 2014[43]
Intermittent Surveillance and Research	Based on the relative risk of HIV compared to non-client males	25	Classic PAF of sex work on prevalent HIV infections, males	2.0 (0.0,88.0)	Underestimates the transmission PAF in the medium to long-term	Systematic Review 2014[43]
	Based on the relative risk of HIV compared to general population females	27	Classic PAF of sex work on prevalent HIV infections, females	6.5 (0.4,71.2)	Underestimates the transmission PAF in the medium to long-term	Systematic Review 2014[43]
	Dynamic mathematical models	3	Transmission PAF over 20 years	58.3-88.9 (in the absence of FSW interventions)	Data requirements (see Table 5); Need dynamic mathematical models calibrated to FSW/client HIV prevalence/incidence trends	Systematic Review 2014[43]

PAF (population attributable fraction)

Table 3. Potential impact of FSW/client interventions on overall HIV transmission in Sub-Saharan Africa [46].

Study	HIV prevalence at start of intervention in the model		Sex work intervention (efficacy, coverage, risk-group)	Potential impact in the wider community				
	Overall	FSWs		Outcome ¹				Time-horizon
				HIV incidence*	HIV prevalence*	# of HIV infections averted	PF	Years
Botswana								
Nagelkerke [110]	30%	N/A	Condom-use (100%, 75%, FSW)		27% [↓] ²			30
Nagelkerke [110]	30%	N/A	Anti-retroviral treatment (100%, 50%, FSW)		13% [↓] ²			30
Vissers [52]	33% ²	N/A	Oral pre-exposure prophylaxis (90%,75%, FSW)			251 per 100,000 uninfected person-years ²		10
Vissers [52]	33% ²	N/A	Oral pre-exposure prophylaxis (90%,75%, FSW and clients)			785 per 100,000 uninfected person-years ²		10
South Africa								
Vickerman [111]	30% ⁴	60%	Vaginal microbicide (40%, 75%, FSW)	1% ² ↓			1.3% ²	4
Vickerman [112]	27% ³	62%	↑ condom-use (100%,20%) & STI treatment (100%, 20%, FSW)	2% ² ↓		53-65 per 100,000 adults ²		1
Vickerman [112]	27% ³	62%	↑ condom-use (100%,20%) & STI treatment (100%, 100%, FSW)	14% ² ↓				1
Vickerman [112]	27% ³	62%	↑ condom-use (100%,20%) & STI treatment (100%, 100%, FSW and clients)	28% ² ↓				1
Johnson [113]	26% ²	N/A	HIV vaccine (30%, 60%, FSW)			0.4-2.4 per 100 FSWs vaccinated ²		10
Zimbabwe								
Hallett [51]	22%	N/A	Condom use (100%,80-100, FSW) & STI treatment (100%,10%, FSW)	10% ² ↓				5
Hallett [51]	22% ²	N/A	Condom use (100%,80-100, FSW) & STI treatment (100%,10%, FSW)	35% ² ↓				10
Kenya								
Vissers [52]	16% ²	N/A	Oral pre-exposure prophylaxis (90%,75%, FSW)			166 per 100,000 uninfected person-years ²		10
Vissers [52]	16% ²	N/A	Oral pre-exposure prophylaxis (90%,75%, FSW and clients)			733 per 100,000 uninfected person-years		10
Decker [114]	6%	33.8%	↓ prevalence of sexual violence from baseline 32% to 2.4%			53,200 ²	12% ²	5
Wirtz [115, 116]	6%	33.8%	100% FSW community empowerment from 5% ; leads to ↑ consistent condom use by 51%			16,661-20,680	6% ²	5
Steen[24]	24% ²	45%	↑ Condom-use (85%, 100%, FSW)	63% [↓] ²	46% [↓] ²			20
Benin								
Boily [9]	1% ²	53%	↑ Condom-use (100%,60%, FSW) & STI treatment (100%,50%, FSW)	19% ³ ↓			58-85%	10
Vickerman [117]	3% ²	55%	↑ Condom-use (100%, 81%, FSW)	21.5% ² ↓ (17.7-24.9)				4
Vickerman [117]	3% ²	55%	STI testing & treatment (80%,85%, FSW)				10% (6-12) ²	4
Vickerman [111]	3.3% ⁴	49%	Vaginal microbicide (40%,75%, FSW)	26% ² ↓			24.8%	4
Williams[13]	3.0% ²	55%	↑ Condom-use (100%, 87.7%, FSW)				33% (20-46)	15

FSW (female sex worker); GP (general population); PF (prevented fraction; the % of HIV infections averted); N/A (not available from the study);

*Relative change in HIV incidence or prevalence; ¹Range, uncertainty bounds, or 95% credible intervals from multiple simulations or epidemic realizations are shown in brackets.

²Total population (i.e. including FSWs and clients); ³General population females (i.e. excluding FSWs); ⁴Ante-natal clinic surveillance

Systematic review of mathematical modeling studies (updated January 2014) generated from the peer-reviewed literature . Studies were included if they used dynamical models of heterosexual HIV transmission, incorporated behavioural heterogeneity in risk, and provided at least one of the following primary estimates in the wider community (a) the population attributable fraction (PAF) of HIV infections due to sexual partnerships within high-risk groups, or (b) the number per capita or fraction of HIV infections averted, or change in HIV prevalence/incidence due to focused interventions.