# Online Appendix

# Equation used to estimate the relative increase in individual risk of HIV infection from forced sex in high and low conflict settings

This modelling uses a static model that estimates an individual’s risk of HIV in a conflict scenario, and compares with their risk if they were not in that setting. To do this, and as described below, an established mathematical equation that describes the probability of HIV acquisition (in which perpetrator HIV/STI prevalence could be varied) was adapted to incorporate the increased risk of HIV if genital injury occurs during sex. Incorporating the potential effect of genital injury, the probability of HIV acquisition over a specified timeframe can be written as follows:

$$π=1-\left\{1-p\left〈1-s\left[h\left(1-αδβ\left[gγ+\left(1-g\right)\right]\right)^{n}+\left(1-h\right)\left(1-δβ\left[gγ+\left(1-g\right)\right]\right)^{n}\right]+\left(1-s\right)\left[h\left(1-αβ\left[gγ+\left(1-g\right)\right]\right)^{n}+\left(1-h\right)\left(1-β\left[gγ+\left(1-g\right)\right]\right)^{n}\right]\right〉\right\}^{m}$$

Where:

* *p* is the probability that a sexual partner or perpetrator is HIV infected;
* *m* is the average number of sexual partnerships per timeframe;
* *n* is the average number of sexual acts per partnership per timeframe;
* ** is the probability of HIV transmission per sex act;
* *h* is the probability that an HIV-infected person has high viraemia;
* *s* is the probability that within a sexual encounter at least one person has a STI;
* ** is the multiplicative increase in the per sex act probability of HIV transmission during the high viraemia phase;
* **is the multiplicative increase in the per sex act probability of HIV transmission in the presence of another STI (infecting either the person at risk or the partner/perpetrator);
* *g* is the probability of genital injury during sex; and
* is the multiplicative cofactor for genital injury.

The above equation can be simplified using Taylor Series linear expansions (about zero) to approximate **:

$$π≅mnpβ\left[gγ+\left(1-g\right)\right]\left[s\left(δ-1\right)+1\right]\left[h\left(α-1\right)+1\right]$$

This approximation will hold if $αδβ\left[gγ+\left(1-g\right)\right]$ and $npβ\left[gγ+\left(1-g\right)\right]\left[s\left(δ-1\right)+1\right]\left[h\left(α-1\right)+1\right]$ are sufficiently small, and *m* is also not too large to warrant the need for the second term in the expansion. Using this equation to estimate a person’s risk in a conflict setting, and comparing this with a non-conflict setting, the risk ratio can then be written:

$$Risk ratio=\frac{π\_{1}}{π\_{2}}≅\frac{m\_{1}n\_{1}p\_{1}β\_{1}\left[gγ+\left(1-g\right)\right]\left\{\left[1-\left(1-S\_{f}\right)\left(1-S\_{m1}\right)\right]\left(δ-1\right)+1\right\}}{m\_{2}n\_{2}p\_{2}β\_{2}\left\{\left[1-\left(1-S\_{f}\right)\left(1-S\_{m2}\right)\right]\left(δ-1\right)+1\right\}}$$

$$ =\hat{m}\hat{n}\hat{p}\hat{β}\left[gγ+\left(1-g\right)\right]\frac{\left\{\left[1-\left(1-S\_{f}\right)\left(1-S\_{m1}\right)\right]\left(δ-1\right)+1\right\}}{\left\{\left[1-\left(1-S\_{f}\right)\left(1-S\_{m2}\right)\right]\left(δ-1\right)+1\right\}}$$

Where:

* *S* is STI prevalence in females or males at risk (*f*) and male partners/perpetrators (*m*)
* Subscript 1 denotes conflict scenario and 2 denotes comparison scenario
* ^ denotes multiplicative cofactor such that etc.


# Equation used to estimate the proportional increase in HIV incidence due to forced sex in high and low conflict settings

Building upon the modelling of increased individual risk, an analytical equation was developed to estimate the probability of HIV infection (I) among susceptible women, incorporating the probability that the woman was raped. *I* can be written:

$$I=1-\left\{(1-i)\left[\left(1-r\right)+r\left(1-π\right)\right]\right\}$$

$$ =1-\left\{(1-i)\left(1-rπ\right)\right\}$$

$$=rπ\left(1-i\right)+ i$$

where:

* *i*  is the incidence of HIV in the absence of rape over a specified timeframe,
* *r* is the proportion of women raped by one or more men, over the timeframe
* $π $is the probability of HIV transmission following rape, that as before can be written:

$$π=1-\left\{1-p\left〈1-s\left[h\left(1-αδβ\left[gγ+\left(1-g\right)\right]\right)^{n}+\left(1-h\right)\left(1-δβ\left[gγ+\left(1-g\right)\right]\right)^{n}\right]+\left(1-s\right)\left[h\left(1-αβ\left[gγ+\left(1-g\right)\right]\right)^{n}+\left(1-h\right)\left(1-β\left[gγ+\left(1-g\right)\right]\right)^{n}\right]\right〉\right\}^{m}$$

The relative proportional increase in HIV incidence (*R*) due to rape is given by:

$$R=\frac{rπ\left(1-i\right)}{i}$$

Again, $π$ can be approximated as follows:

$$π≅mnpβ\left[gγ+\left(1-g\right)\right]\left[s\left(δ-1\right)+1\right]\left[h\left(α-1\right)+1\right]$$

Substituting this into the above equation, the relative proportional increase in HIV incidence (*R)* can be written:

$$R≅\frac{rmnpβ\left[gγ+\left(1-g\right)\right]\left[s\left(δ-1\right)+1\right]\left[h\left(α-1\right)+1\right](1-i)}{i}$$