## Abstract

We build a simple model for an STI in Papua New Guinea, and use an existing model to determine its effect on HIV. Our model considers three main outputs: decrease in syphilis prevalence, decrease in HIV incidence, and time taken for 90% of the intervention’s effect on syphilis to happen.

## Definitions

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| Term or abbreviation | Definition |
| FSW | Female sex workers |
| MSMW | Men who have sex with men and women |
| Incidence (of a disease per unit time) | Number of new cases of that disease in that time |
| Prevalence (of a disease) | Proportion of people who have that disease |
| PNG | Papua New Guinea |

## Underlying model

We have built a compartmental SIS-SIRS model in discrete time. We split the population into general males, men who have sex with men and women (MSMW), general females, and female sex workers (FSW). The male and general female populations can only be either susceptible or infected. Infected people return to the susceptible population at a constant rate. The female sex worker population can also only be either susceptible or infected in the baseline scenario, and return from infected to susceptible at the same constant rate.

Our model has the following structure:

Susceptible

6

2

5

1

3

Infected

4

Resistant

|  |  |  |  |
| --- | --- | --- | --- |
| Arrow | Description | Formula (m1) | Footnote |
| 1 | Infection rate |  | m2 |
| 2 | Existing treatment and loss rate |  | m3 |
| 3 | PPT rate for susceptible |  | m4 |
| 4 | PPT rate for infected |  | m5 |
| 5 | Movement off PPT, then remain susceptible for one period |  | m6 |
| 6 | Movement off PPT, then become infected in the same period |  | m7 |
| m1: These formulas are for FSWs only. For different sub-populations, is replaced with a different parameter and the exponent of vary, as follows:   |  |  |  | | --- | --- | --- | | Sub-population |  | Exponent | | FSW |  |  | | General females | (Low Risk) |  | | General males | (Low Risk) |  | | MSMW |  |  |   m2: Many SIRS models would use the formula instead of the formula given above. However, that common formula has the drawback that for all and , doubling and would double the number of people infected. In practice, for relatively large , doubling both and would not quite double the number of people infected, because once somebody has been infected once, they cannot be infected again. Our formula is the CDF of an exponential distribution with rate , evaluated at .  m3: This accounts for all treatment other than PPT, as well as losses and births. Congenital syphilis has a very high mortality rate, and very few people infected at birth survive to enter the sexual population.  m4-m5: Because this only accounts for | | | |

Numerically, our model for the baseline scenario is the following:

General males:

MSMW:

General females:

FSW:

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| --- | --- | --- |
| Parameter | Description | Typical value |
|  | Proportion of respectively general males, MSMW, general females and FSW susceptible at time | 0.93, 0.92, 0.91, 0.68 |
|  | Proportion of respectively general males, MSMW, general females and FSW infected with STI at time | 0.07, 0.08, 0.09, 0.32 |
|  | Proportion of respectively general males, MSMW, general females and FSW who have treatment-induced resistance at time | (see below) |
|  | Combined treatment rate before intervention, and loss rate | 1/ |
|  | Fraction of male sex acts with general females | 0.62 |
|  | Fraction of female sex acts with general males | 0.96 |
|  | Average probability that a susceptible general male will not be infected within one period |  |
|  | Average probability that a susceptible MSMW not be infected in one period |  |
|  | Average probability that a susceptible general female will not be infected within one period |  |
|  | Average probability that a susceptible general FSW will not be infected within one period |  |

are rate parameters describing the rate of treatment associated with the intervention. We assume that people receive treatment according to their sub-population, at a constant rate.

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|  | Rate of effective intervention treatment for FSW |  |
|  | Rate of effective intervention treatment for MSMW |  |
|  | Rate of effective intervention treatment for general males and general females |  |
|  | Average number of PPT sessions per year for FSW | 0.4 |
|  | Fraction of the number of PPT sessions for FSW per year which MSMW receive | 0 |
|  | Fraction of the number of PPT sessions for FSW per year which general males and general females receive | 0 |
|  | Initial effectiveness of PPT | 0.98 |
|  | Increase in resistance to PPT of STI | 0.01 |
|  | Modifier based on the region |  |

## Results

A full description of the results is provided in the Appendix. With a coverage of 40% for all MSMW and FSW in PNG, and with no coverage for general females or males, there is a x% fall in the equilibrium prevalence of syphilis. Syphilis prevalence falls 90% of the distance towards this level by xxxx. This causes a x% fall in HIV incidence by xxxx.

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| --- | --- | --- | --- |
| Scenario | Percentage drop in syphilis after 10 years | Time it takes for syphilis to fall to 90% towards this level | Percentage drop in HIV after 10 years |
| Default scenario | X | X | X |

Figure: smallsti output

Figure: HIV incidence

Comparing the effectiveness of a scenario where we treat the whole population to a scenario where we treat only FSW, we see an improvement in effectiveness of x%. Compared to a scenario where we treat FSW and MSMW, we see an improvement of x%.

## Appendix

Figure x: results of model

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| --- | --- | --- | --- |
| Scenario | Percentage drop in syphilis after 10 years | Time it takes for syphilis to fall to 90% towards this level | Percentage drop in HIV after 10 years |
| Default intervention | 0.6697 | 0.917 | 7.2212 |
| Increase to 0.70 | 0.6937 | 0.8589 | 7.4685 |
| Decrease to 0.56 | 0.6557 | 0.8679 | 7.07 |
| Increase to 0.99 | 0.6871 | 0.8649 | 7.1662 |
| Decrease to 0.92 | 0.6468 | 0.8511 | 7.2788 |
| Increase to 0.50 | 0.3217 | 0.7423 | 6.8204 |
| Increase to 1.00 | 0.1374 | 0.7423 | 6.3265 |
| Decrease to 0.75 | 0.6753 | 0.8619 | 7.2212 |
| Increase to 1.25 | 0.6646 | 0.8562 | 7.2238 |
| Decrease to 0.00 | 0.7228 | 0.9019 | 6.155 |
| Decrease to 0.50 | 0.6945 | 0.8778 | 7.1485 |
| Decrease to 0.00 | 0.9469 | 0.9562 | 1.0854 |
| Decrease to 0.50 | 0.8013 | 0.9028 | 6.7746 |
| Decrease to 0.20 | 0.8261 | 0.9219 | 6.7019 |
| Increase to 0.60 | 0.5334 | 0.809 | 7.6527 |
| Decrease to 0.90 | 0.6853 | 0.8649 | 7.1662 |
| Increase to 0.98 | 0.6604 | 0.8649 | 7.2596 |
| Decrease to | 0.6161 | 0.845 | 8.6558 |
| Increase to | 0.7157 | 0.874 | 5.8754 |

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| --- | --- | --- | --- |
| Scenario | Percentage drop in syphilis after 10 years | Time it takes for syphilis to fall to 90% towards this level | Percentage drop in HIV after 10 years |
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