**SUPPLEMENTARY MATERIAL**

**Appendix**

**The model.** The model is described by the following equations:



 is the number of uninfected individuals in sexual risk group  and  is the number of individuals infected with NG strain  in sexual risk group . The symbols for the different NG strains are as follows: , strain sensitive to antibiotics A, B, C; , strain resistant only to antibiotic A; , strain resistant only to antibiotic B; , strain resistant to antibiotics A, B; , strain resistant to antibiotics A, B, C. The size of risk group  is . The rate of entering and departing the sexually active population is , the rate of natural recovery is  for those infected with NG strain , and the treatment rate is . Among NG cases receiving treatment, a fraction  is prescribed only antibiotic A, a fraction  is prescribed only B, and a fraction  receives combination therapy with A and B, with . The fraction of hosts becoming resistant is  when treated with one antibiotic and  when treated with two antibiotics [1]. An individual infected from a partner with NG strain resistant to antibiotics, acquires the same NG strain and is resistant to the same antibiotics. Individuals with resistance to antibiotic A who receive A are not successfully treated; a fraction  of them is later re-treated with antibiotic B. For the scenarios with re-treatment, ; for the other scenarios, . For the scenario of combination therapy with A and B, a fraction  of those with dual resistance to A and B is later re-treated with antibiotic C; for the other scenarios, .

**Transmission rate of NG.** The rate at which men in activity group  get infected with NG is , where  is the rate at which men in activity group  get infected with NG strain  as defined from the equations:

.

The probability of transmission of NG strain  per act of UAI is , with , for , where  denotes the fitness cost of resistance, compared to the sensitive strain . Also,  ,  ,  are the numbers of steady, single-act, multiple-acts casual partners;  and  denote the number of acts of UAI per year per partner, for steady and multiple-acts casual partnerships. Based on data from Rutgers WPF Group,  was taken in the range 15-25 acts per year and  in the range 1-7 acts per year (see also [2]). Mixing between risk groups *i, j* = 1,2,3,4 is defined by  for steady partners:



by  for single-act casual partners and  for multiple- acts casual partners:

 and 

where is the Kronecker delta, being equal to 1, if , and equal to 0, if . The parameter  determines the level of assortativeness in mixing: if , then mixing is purely assortative; if , then mixing is purely proportionate. Similarly,  and  determine the levels of assortativeness in mixing with single-act and multiple-acts casual partners. We found no data to inform the mixing parameters, but earlier studies have indicated that sexual mixing is mostly assortative with steady long-lasting partnerships, but less assortative with casual partners [3, 4]. Therefore, for steady partners, we assumed that  is between 50% and 90%, while for casual partners,  and  are in the range 30-70%.

**The four sexual risk groups**

In the model, MSM may have steady partners, single-act casual partners (with whom they have only one UAI act), and multiple-acts casual partners (with whom they have multiple sexual contacts). The population is divided into four risk groups according to the number of partners. MSM in risk group 1 have no casual partners. MSM in groups 2, 3, and 4 have steady and casual partners, with increasing total number of partners from group 2 to group 4. Parameters relating to sexual behavior were mostly obtained from data from the Amsterdam Cohort Study among MSM (see [2] and references therein). The fraction of the population in risk group 1, 2, 3, 4 is 70%, 20%, 7%, 3%, respectively. The annual rates of partner change for MSM in risk group 1, 2, 3, and 4 are:

* For steady partners: 0.27, 0.26, 0.32, and 0.54, respectively;
* For single-act casual partners: 0, 1.36, 4.52, and 20.6, respectively;
* For multiple-act casual partners: 0, 1.36, 3.48, and 13, respectively.

**REFERENCES**

1. **Bonhoeffer S, Lipsitch M, Levin BR.** Evaluating treatment protocols to prevent antibiotic resistance. *Proceedings of the National Academy of Sciences USA* 1997; **94**: 12106-12111.

2. **Xiridou M, *et al*.** Modelling the impact of chlamydia screening on the transmission of HIV among men who have sex with men. *BMC Infectious Diseases* 2013; **13**: 436.

3. **Garnett GP, *et al*.** Sexual mixing patterns of patients attending sexually transmitted diseases clinics. *Sexually Transmitted Diseases* 1996; **23**: 248-257.

4. **Schneider JA, *et al*.** Network mixing and network influences most linked to HIV infection and risk behavior in a Black men who have sex with men HIV epidemic. *American Journal of Public Health* 2013; **103**: e28-e36.