**Supplementary material**

1. **Initialization algorithm and transmission and recovery algorithm**

**Explanation on the notations used:**

* $i$: the anatomical site of infection, $i\in \left\{R,U,P\right\}$;
* $wc\_{i}$: fraction of people initially infected in site $i$ with susceptible strain;
* $qc\_{ij}$: fraction of people initially infected in sites $i$ and $j$ with susceptible strain;
* $l$: fraction of people initially infected with symptomatic infection in urethra;
* An infectious profile: $(i,s, r) $
	+ $i$ is the anatomical site of infection, $i\in \{R,U,P\}$;
	+ $r$ is the resistance profile that takes 0 for susceptible to ceftriaxone and 1 for resistant to ceftriaxone;
	+ $s$ is the symptom status: 0 for asymptomatic and 1 for symptomatic;
* $β:$ yearly rate of sexual acts;
* $k\_{i,j}$: the probability that a sexual act is between anatomical sites $i$ and $j$;
* $m\_{i,j}$: the probability that a sexual act between anatomical sites $i$ and $j$ leads to the transmission of infection;
* $p\_{j}$: the probability that an infection in anatomical site $j$ will become symptomatic (it was assumed that $p\_{R}=p\_{P}=0$);
* $f\_{i}$: average time until natural recovery for asymptomatic infection at site $i$;
* $u$: average time between screening episodes;
* $z$: average time until seeking treatment for individuals with symptomatic urethral infection;
* $v$: average time until recovery after receiving treatment;
* $x$: probability of developing resistance while under treatment.

**Initialization algorithm**

1. A population of $n$ susceptible agents is created.

2. a. An agent is infected at pharynx with a drug-susceptible strain with the probability $w\_{P}$;

 b. An agent is infected at rectum with a drug-susceptible strain with the probability $w\_{R}$;

 c. An agent is infected at urethra with a drug-susceptible strain with the probability $w\_{R}$; the infection becomes symptomatic with the probability $l$.

1. An agent is infected at rectum and pharynx with a drug-susceptible strain with the probability $q\_{RP}$; the infection becomes symptomatic in urethra with the probability $l$.
2. An agent is infected at rectum and urethra with a drug-susceptible strain with the probability $q\_{RU}$; the infection becomes symptomatic in urethra with the probability $l$.
3. An agent is infected at pharynx and urethra with a drug-susceptible strain with the probability $q\_{PU}$; the infection becomes symptomatic in urethra with the probability $l$.

**Transmission and recovery algorithm**

1. Individuals with infectious profile $(i, r, s)$ with $i\in \{U,P\}$, $r\in \left\{0,1\right\} $and $s\in \left\{0,1\right\}$ send the following messages:
	1. $(j, r, 1)$, with $j\in \{R,U,P\}$, $r\in \left\{0,1\right\}$ at the rate $βk\_{i,j}m\_{i,j}p\_{j}$ and if those receiving the message will develop symptomatic infection at site $j$ with resistance status $r$;
	2. $(j, r, 0)$, with $j\in \{R,U,P\}$, $r\in \left\{0,1\right\}$ at the rate $βk\_{i,j}m\_{i,j}(1-p\_{j})$ and those receiving the message will develop asymptomatic infection at site $j$ with resistance status $r$.
2. Individuals with infectious profile $(i, r, s)$ with $i\in \{R\}$, $r\in \left\{0,1\right\} $and $s\in \left\{0,1\right\}$ send the following messages:
	1. $(j, r, 1)$, with $j\in \{U,P\}$, $r\in \left\{0,1\right\}$ at the rate $βk\_{i,j}m\_{i,j}p\_{j}$ and those receiving the message will develop symptomatic infection at site $j$ with resistance status $r$;
	2. $(j, r, 0)$, with $j\in \{U,P\}$, $r\in \left\{0,1\right\}$ at the rate $βk\_{i,j}m\_{i,j}(1-p\_{j})$ and those receiving the message will develop asymptomatic infection at site $j$ with resistance status $r$.
3. Individuals with infectious profile $(i, r, s)$ with $i\in \{R,U, P\}$, $r\in \{0,1\}$ and $s=0$ recover naturally$. $Time until natural recovery follows an exponential distribution with rate $f\_{i}$.
4. Individuals with infectious profile $(i, r, s)$ with $i\in \{R,U, P\}$, $r\in \{0,1\}$ and $s=0$ undergo screening. Time between screening episodes follows an exponential distribution with rate $u$.

Immediately after individuals receive the first-line treatment.

1. Individuals with infectious profile $(i, r, s)$ with $i=U$, $r\in \{0,1\}$ and $s=1$ seek the first line treatment. Time until seeking treatment for individuals with symptomatic urethral infection follows an exponential distribution with rate $z$.
2. a. Individuals with infectious profile $(i, r, s)$ with $i\in \{R,U,P\}$, $r=0$ and $s\in \{0,1\}$ receive the first-line treatment. Time until recovery after receiving the first-line treatment follows an exponential distribution with rate $v$ . During the treatment, the infection might develop resistance with the probability $x$, which results in changing the resistance status of infection to $r=1$. If resistance is not developed, the individual recovers in this site.

b. The first-line therapy is not successful on infectious profiles$ (i, r, s)$ with $i\in \{R,U,P\}$, $r=1$, and $s\in \{0,1\}$, and does not change the infectious profile.

c. In case of individuals being infected in two sites with infectious profiles $(i, r, s)$ with $i\in \{R,U,P\}$, $r=0$ and $s\in \{0,1\}$, the infection might develop resistance with the probability $x$ in one site or it might develop resistance with the probability $x$ in another site, which results in changing the resistance status of infection to $r=1$ in that site. If resistance is not developed, the individual recovers in both sites.

1. Individuals with infectious profile $(U, 1, 1)$ seek re-treatment with the second-line antibiotic (ertapenem). Time until seeking treatment with the second-line antibiotic for individuals with symptomatic urethral infection follows an exponential distribution with rate $z$.
2. Individuals with infectious profile $(U, 1, 1)$ receive the second-line treatment. Time until recovery after receiving the second-line treatment follows an exponential distribution with rate $v$.

The values of the parameters are provided in Tables 1-3.

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| Parameter | Prior distribution  | Source |
| Total population ($n$) | 10,000 |  |
| Fraction of people initially infected at pharynx only with susceptible strain ($w\_{P}$) | uniform(0.8\*0.06, 1.2\*0.06) |  [12] |
| Fraction of people initially infected at rectum only with susceptible strain ($w\_{R}$) | uniform(0.8\*0.035, 1.2\*0.035) | [12] |
| Fraction of people initially infected at urethra only with susceptible strain ($w\_{U}$) | uniform(0.8\*0.025, 1.2\*0.025) | [12] |
| Fraction of people initially infected at rectum and pharynx with susceptible strain ($q\_{RP}$) | uniform(0.8\*0.02, 1.2\*0.02) | [12] |
| Fraction of people initially infected at rectum and urethra with susceptible strain ($q\_{RU}$) | uniform(0.8\*0.0093, 1.2\*0.0093) | [12] |
| Fraction of people initially infected at pharynx and urethra with susceptible strain ($q\_{PU}$) | uniform(0.8\*0.0087, 1.2\*0.0087) | [12] |
| Fraction of people initially infected with symptomatic urethral infection ($l$) | uniform(0.01, 0.3) | Assumption |

Table 1. Initialization parameters

|  |  |  |
| --- | --- | --- |
| Parameter | Prior distribution  | Source |
| Probability that the infection will become symptomatic |  |  |
| $$p\_{R}$$ | 0 |  |
| $$p\_{U}$$ | uniform (0.33, 0.94) | [9-11, 13] |
| $$p\_{P}$$ | 0 |  |
| Yearly rate of sexual acts ($β$) | uniform(0.8\*80, 1.2\*80) | [14] |
| Probability of a sexual act between two anatomical sites |  |  |
| $$k\_{P,P}$$ | 0.83 | [15] |
| $$k\_{P,U}$$ | 0.825 | [15] |
| $$k\_{P,R}$$ | 0.6 | [15] |
| $$k\_{U,R}$$ | 0.478 | [15] |
| $$k\_{U,U}$$ | 0.03 | [15] |
| $$k\_{R,U}$$ | 0.478 | [15] |
| $$k\_{R,P}$$ | 0.6 | [15] |
| $$k\_{U,P}$$ | 0.825 | [15] |
| Probability of transmission from one anatomical site to another |  | Assumption |
| $$m\_{P,P}$$ | uniform (0.001, 0.1) |  |
| $$m\_{P,U}$$ | uniform (0.001, 0.1) |  |
| $$m\_{P,R}$$ | uniform (0.001, 0.1) |  |
| $$m\_{U,R}$$ | uniform (0.001, 0.1) |  |
| $$m\_{U,U}$$ | uniform (0.001, 0.1) |  |
| $$m\_{R,U}$$ | uniform (0.001, 0.1) |  |
| $$m\_{U,P}$$ | uniform (0.001, 0.1) |  |
| $$m\_{R,P}$$ | uniform (0.001, 0.1) |  |

Table 2. Transmission parameters

|  |  |  |
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| Parameter | Prior distribution  | Source |
| Average time until natural recovery at different anatomical sites (years) |  | Assumption |
| $f\_{R}$  | uniform(1/12, 5) |  |
| $f\_{U}$  | uniform(1/12, 5) |  |
| $f\_{P}$  | uniform(1/12, 5) |  |
| Average time until seeking treatment for individuals with symptomatic urethral infection (z) (years) | uniform(1/365, 14/365) | Assumption |
| Average time between screening episodes ($u$) (years) | uniform(1, 10) | Assumption |
| Average time until recovery after receiving treatment ($v$) (years) | uniform(1/365, 14/365) | Assumption based on [16] |
| Probability of developing resistant while under treatment ($x$) | uniform(0.001, 0.009) |  Assumption |

Table 3. Recovery parameters

1. **Histograms of the posterior distributions**

 

 





 

 

Figure 1. Histograms of the posterior distributions.