

S3 Appendix: Derivation of parameter input ranges

Proportion of new infections that develop symptoms - ψ

The proportion of incident infections that are symptomatic is known to vary by site of infection. Traditional modelling attempts using the few empirical studies available estimated the proportion of urethral cases that develop symptoms at 90% to 95% [1–3]. Extra-genital infections are less likely to develop symptoms. In screening studies on MSM attending a sexual health clinics only 15% of rectal and none of the pharyngeal infections detected were symptomatic [4–6]. We therefore consider scenarios in which 40% to 95% of new infections develop symptoms, to reflect scenarios in which 50%-100% of infections are urethral.

Mean duration of incubation period - $1/\sigma$

The incubation period of gonorrhoea, defined as the time from initial infection to exhibiting symptoms of disease, was traditionally thought to be short - in the region of three to five days [2, 7, 8]. It has been suggested that the incubation period may be increasing, perhaps as a result of antibiotics usage, to around 8 days [9, 10]. We therefore considered a range of incubation periods from 2 to 10 days in our simulations.

Mean duration of carriage - $1/\nu$

There is little data on the duration of untreated gonorrhoea, which may depend on infection site. Recovery time for pharyngeal gonorrhoea is estimated at 12 weeks [11, 12]. By contrast, the duration of rectal infection has been estimated at one year [11, 13]. A study of 18 asymptomatic infected men saw no resolution in urethral infection in the 165 days until they received treatment [3]. Estimates of the duration of asymptomatic infection in modelling studies have been based on calculations that take into account observed prevalence and assumed proportion of unobserved infection, and are often in the region of 6 months [1, 14, 15]. This was supported by evidence based on genomic data in which the longest observed time to most recent common ancestor was 8 months [16]. Researchers using high sensitivity diagnostic tools in Namibia found evidence of a much longer duration of carriage. They estimated a 333-day average term of high-level infection before progression to low-level infection [17]. Low-level urethral infections took an average 250 days to resolve without treatment. We therefore considered a range of carriage durations from 2 - 18 months.

Rate of screening - η

The 2010 UK national guidelines on safer sex advice recommend that all MSM are screened for gonorrhoea at least annually, and that highly sexually active MSM are screened at least every three months [18, 19]. However a social media survey of 2,668 MSM in Scotland, Wales and Ireland found that two-thirds of MSM reported STI testing less than once a year [20]. We considered a range of inputs for the rate of screening of $[0.4, 4]$. This corresponds to a range of scenarios: from testing at quarterly intervals, in adherence with the BASHH guidelines, through to the situation described by Frankis et al. The lower bound for eta was calculated by setting the probability of testing less than once a year equal to $\frac{2}{3}$ under an exponential distribution with rate η , so that $\mathcal{P}[T > 1] = e^{-\eta} = \frac{2}{3}$, and solving to find $\eta = -\ln \frac{2}{3} = 0.4$.

The mean time to treatment seeking when symptomatic ($1/\mu$) and mean time to recovery following treatment ($1/\rho$) were set to be in the region of days rather than weeks.

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