Estimating incidence and prevalence of sexually transmissible infections in Australia

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The reported numbers of diagnosed notifiable Sexually Transmitted Diseases (STIs) in Australia are subject to a myriad of biases and limitations. Demographic, clinical, behavioural and temporal factors combine to prevent direct use of raw notification data for public health research. Trends in diagnosis rates may not reflect trends in true underlying incidence. Given that the incidence and prevalence of an infection are critical epidemiological measures for understanding the transmission and extent of disease in a population, this MISG project sought to develop mathematical and statistical techniques to estimate the true incidence and prevalence of infection within the Australian population for a number of bacterial STIs.

An important limitation for the scope of the project was that only routinely available data, with supplemental information available from the existing published literature, may be used for estimation purposes. New epidemiological surveillance protocols to address shortcomings in data have been deemed unsuitable due to cost and logistical constraints.

Of the multiple bacterial STIs for which estimations are required, data on chlamydia infection is the most complete. The MISG team focussed on the development of two complementary methods to estimate annual chlamydia incidence, with the hope that findings would prove useful for estimation of incidence for the other diseases of interest, gonorrhoea and syphilis.

Figure 1, as developed by the group, presents a probability model for esti-

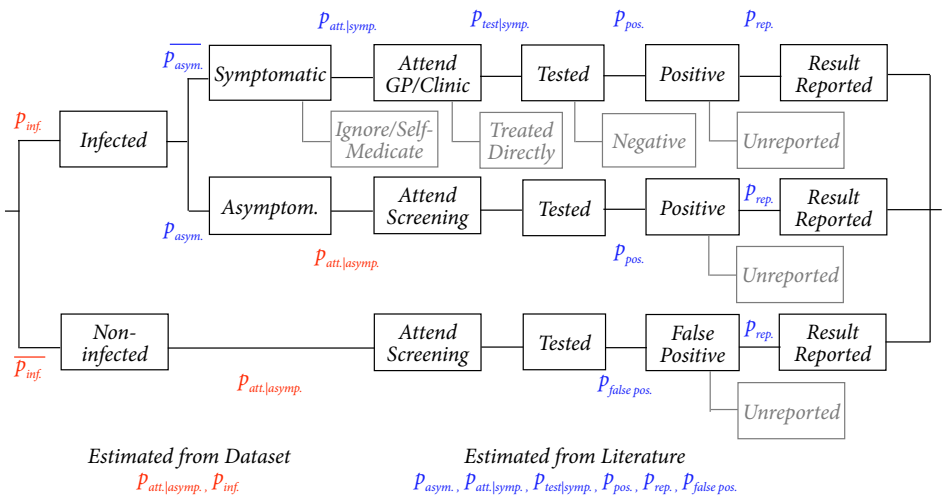

Figure 1: Tree diagram for estimation of annual chlamyda incidence in Australia.

mation of the incidence of chlamydia. Probabilities in blue where established through consultation with the Kirby Institute industry representatives and a thorough search of the epidemiological literature, leaving just two probabilities, P_{inf} and $P_{att.|asymp}$ to be estimated from the raw case series data contained in the National Notifiable Disease Surveillance System, and further routinely collected data on the number of tests for Chlamydia that are captured through the Medicare system. With two variables and two data sources, the system is well-posed and following some algebra analytic expressions for the two unknown probabilities were determined.

The statistical model was coded up in R, and formulated in a Bayesian framework using Monte Carlo sampling of parameters derived from the literature to allow for calculation of the credible range for year-on-year 'true' incidence for chlamydia. A preliminary estimate for chlamydia incidence using the model aligned with pre-existing expectations of the Kirby Institute representatives. Further work to extend the model to estimate annual incidence rates for gonorrhoea and syphilis is ongoing.

The second method used to estimate chlamydia infection rates in Australia was a compartmental mathematical model. A set of ordinary differ-

ential equations describing the transmission and treatment of, and recovery from, infecton was coded up in Matlab. Model parameterisation was largely achieved through consultation with the Kirby representatives and a review of the publisehd literature. The simple framework of the model ensured that only two parameters were left 'free': the transmission coefficient and the rate at which asymptomatic carriers received treatment - the two most important unknowns. The model was fitted (minimizing residuals) to monthly incidence data collected between 1999 and 2013. Again, further work to extend the model to simulate gonorrhoea and syphilis incidence is ongoing.