

COVID-19 Model Containing Contact Tracing and Quarantine

1 Model Equations

The previous model it is unclear what is meant by quarantining. Quarantining of symptomatic people? Then why are S and E quarantined? Or is instead what is intended self-isolation? If so, why are I_P not potentially placed into self-isolation?

Below is what I suggest for the formulation of contact-tracing:

$$\frac{dS}{dt} = -Sac \left(\frac{I_P + b_C I_C + b_A I_A}{N} \right) + \delta_{Q_S} Q_S \quad (1)$$

$$\frac{dE}{dt} = (1 - \lambda) Sac \left(\frac{I_P + b_C I_C}{N} \right) + Sac \frac{b_A I_A}{N} - \delta_E E \quad (2)$$

$$\frac{dI_P}{dt} = r\delta_E E - \delta_{I_P} I_P \quad (3)$$

$$\frac{dI_C}{dt} = \delta_{I_P} I_P - \delta_{I_C} I_C \quad (4)$$

$$\frac{dI_A}{dt} = (1 - r)\delta_E E - \delta_{I_A} I_A \quad (5)$$

$$\frac{dR_S}{dt} = \delta_{I_C} I_C + \delta_{Q_{RS}} Q_{RS} - \lambda ac R_S \left(\frac{I_P + b_C I_C}{N} \right) \quad (6)$$

$$\frac{dR_A}{dt} = \delta_{I_A} I_A + \delta_{Q_{RA}} Q_{RA} - \lambda ac R_A \left(\frac{I_P + b_C I_C}{N} \right) \quad (7)$$

$$\frac{dQ_S}{dt} = \lambda S(1 - a)c \left(\frac{I_P + b_C I_C}{N} \right) - \delta_{Q_S} Q_S \quad (8)$$

$$\frac{dQ_E}{dt} = \lambda Sac \left(\frac{I_P + b_C I_C}{N} \right) - \delta_E Q_E \quad (9)$$

$$\frac{dQ_{I_P}}{dt} = r\delta_E Q_E - \delta_{I_P} Q_{I_P} \quad (10)$$

$$\frac{dQ_{I_C}}{dt} = \delta_{I_P} Q_{I_P} - \delta_{I_C} Q_{I_C} \quad (11)$$

$$\frac{dQ_{I_A}}{dt} = (1 - r)\delta_E Q_E - \delta_{I_A} Q_{I_A} \quad (12)$$

$$\frac{dQ_{R_S}}{dt} = \lambda ac R_S \left(\frac{I_P + b_C I_C}{N} \right) + \delta_{I_C} Q_{I_C} - \delta_{Q_{RS}} Q_{RS} \quad (13)$$

$$\frac{dQ_{R_A}}{dt} = \lambda ac R_A \left(\frac{I_P + b_C I_C}{N} \right) + \delta_{I_A} Q_{I_A} - \delta_{Q_{RA}} Q_{RA} \quad (14)$$

where a is the probability of infection given a contact, c is the rate of contact between individuals, and λ is the probability that an infected individual is placed in quarantine after having been identified as a contact. I recommend drawing out this model to check it and also reading the relevant sections of the Otto & Day textbook (available at MUN library as an ebook).

One assumption of the above formulation is that the rate of being placed into quarantine after being contacted is the same for I_P and I_C , however, this would not be true since I_P is not likely to have yet tested positive. However, correcting this make the system of ODEs very large, and it might be better to move to a system of delay differential equations.