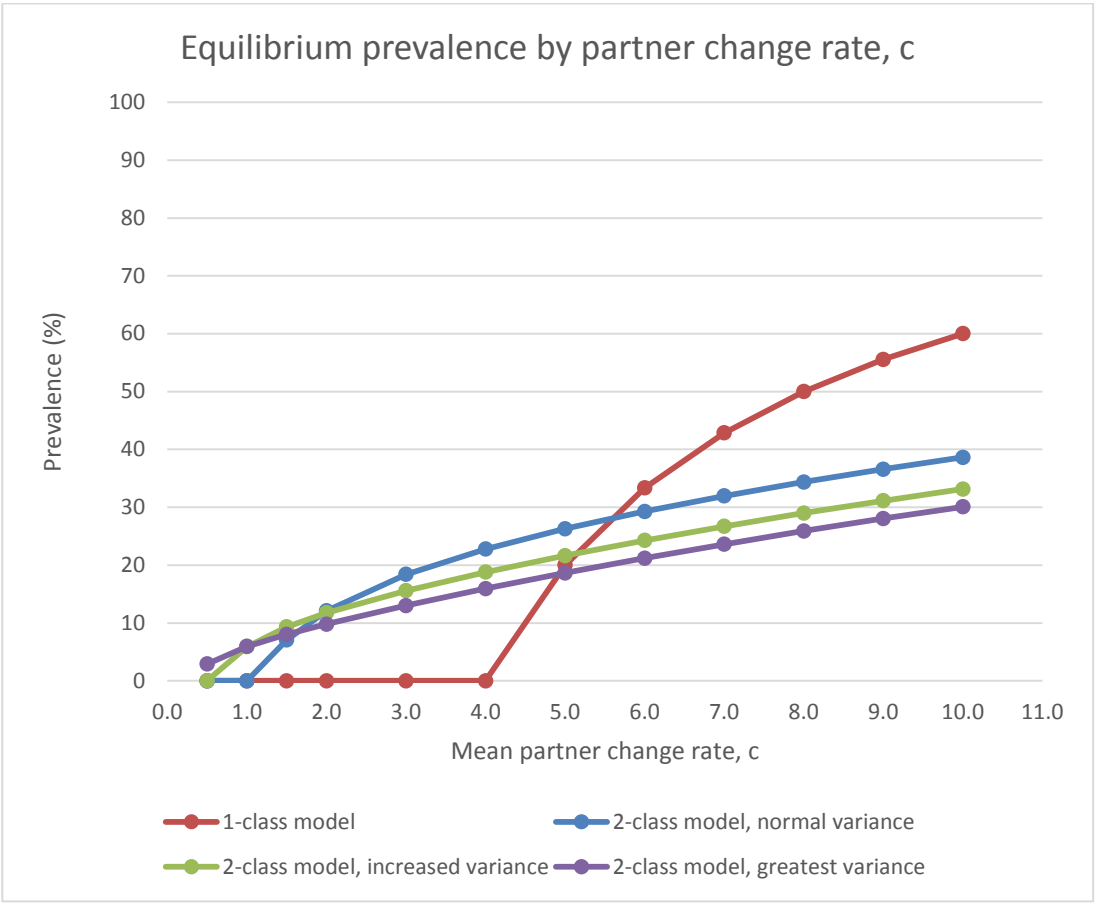
Part 1

Exercise 1	Equilibrium prevalence (%)			
Mean partner change rate, c	1-class model	2-class model, normal variance	2-class model, increased variance	2-class model, greatest variance
0.5	0.00	0.00	0.00	2.90
1.0	0.00	0.00	5.90	5.96
1.5	0.00	7.05	9.31	8.02
2.0	0.00	12.08	11.76	9.81
3.0	0.00	18.41	15.58	13.01
4.0	0.01	22.78	18.78	15.93
5.0	20.00	26.28	21.64	18.65
6.0	33.33	29.28	24.27	21.20
7.0	42.86	31.95	26.70	23.61
8.0	50.00	34.36	28.99	25.89
9.0	55.56	36.58	31.13	28.04
10.0	60.00	38.63	33.15	30.08
		h:I = 25, propn high = 0.20	h:I = 50, propn high = 0.10	h:I = 100, propn high = 0.05



- What do you expect the threshold rate of sex partner change for persistence of infection to be in the homogeneous-behaviour (1-class) case and the heterogeneous behaviour (2-class) case?

  - a partner change rate of 4 for the 1-class model

    $R_0 = \beta.c.d$

    $1 = \beta.c.d$ - threshold for persistence of infection

    $c = 1/\beta.d$ - rearrange to express in terms of c (partner change rate)

    $= 1/(0.5*0.5)$ - substitute the parameter values used

    $= 1/0.25$ - calculate the threshold rate of partner change

    $= 4$

  - the threshold is much lower for the 2-class model (< 1)

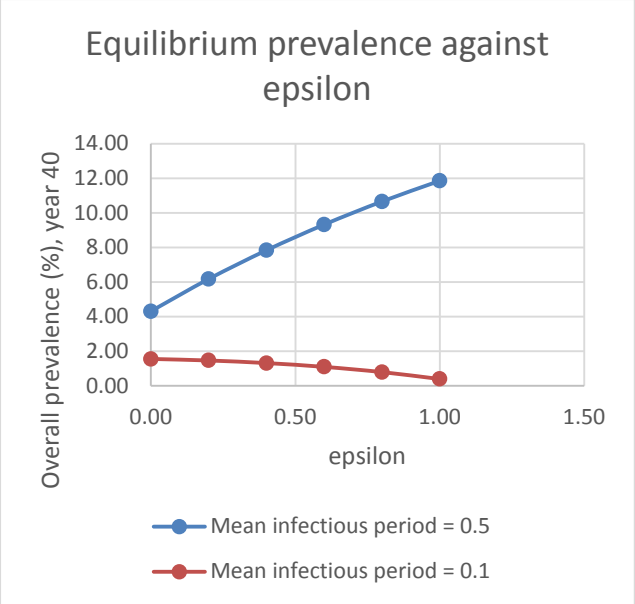
- Is this supported by trying different values in the model?
  - yes

- What is the influence of increased variance in behaviour (increased heterogeneity) on the equilibrium prevalence of infection?
  - persistence of infection at lower levels of partner change rates
  - at higher levels of partner change, endemic prevalence decreases with increasing heterogeneity

The partner change rate is important, but does not provide the complete picture. Patterns of mixing across risk groups are also important (as illustrated by the following two questions).

Part 2

Exercise 2	Overall prevalence, year 40	
epsilon	Mean infectious period = 0.5	Mean infectious period = 0.1
0.00	4.31	1.55
0.20	6.17	1.46
0.40	7.83	1.31
0.60	9.32	1.09
0.80	10.65	0.79
1.00	11.85	0.39



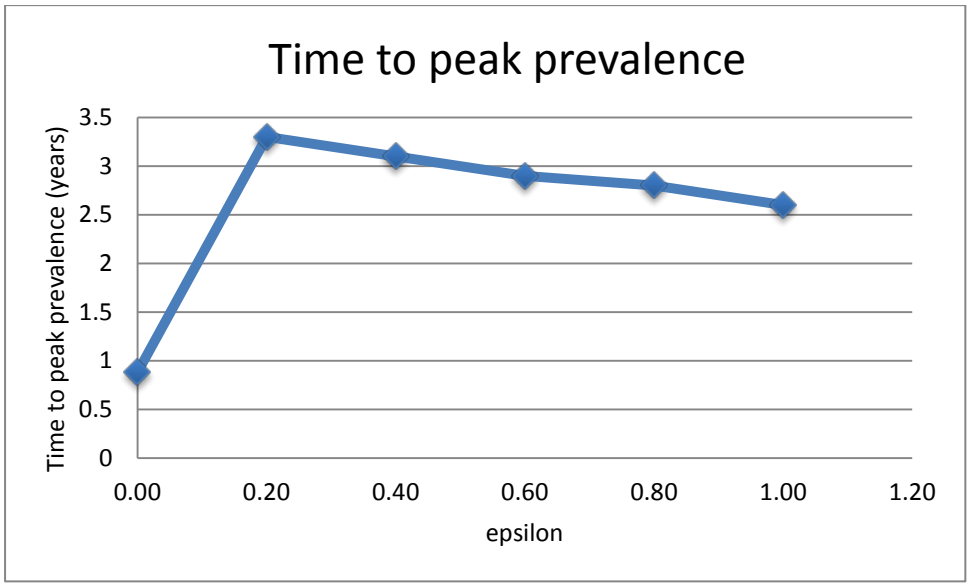
- What is the influence of the mixing pattern on the equilibrium prevalence?
  - in the absence of treatment (low recovery rate): increasing randomness produces increasing equilibrium prevalence
  - in the presence of treatment (high recovery rate): increasing randomness produces a slight decrease in equilibrium prevalence

Generally, if high activity people, who are most likely to transmit infection, choose sex partners randomly, then infection will spread widely by generating a flow of infection from the high to the low activity group. However, different recovery rates can produce a different relationship between epsilon and equilibrium prevalence:

- a recovery rate of 2 (6 months) is sufficiently slow to allow prevalence to increase as mixing tends towards being random (i.e. with increasing mixing between the high and low risk groups)
- whereas, a recovery rate of 10 (a tenth of a year) is much faster, so individuals are infectious for a shorter period of time, and therefore have less opportunity to transmit, therefore equilibrium prevalence decreases as mixing tends towards being random, because infection spreading from high- to low-activity individuals will break chains of infection and reduce how far infection can spread.

Part 3

Exercise 3	
epsilon	Time to peak prevalence
0.00	0.88
0.20	3.3
0.40	3.1
0.60	2.9
0.80	2.8
1.00	2.6



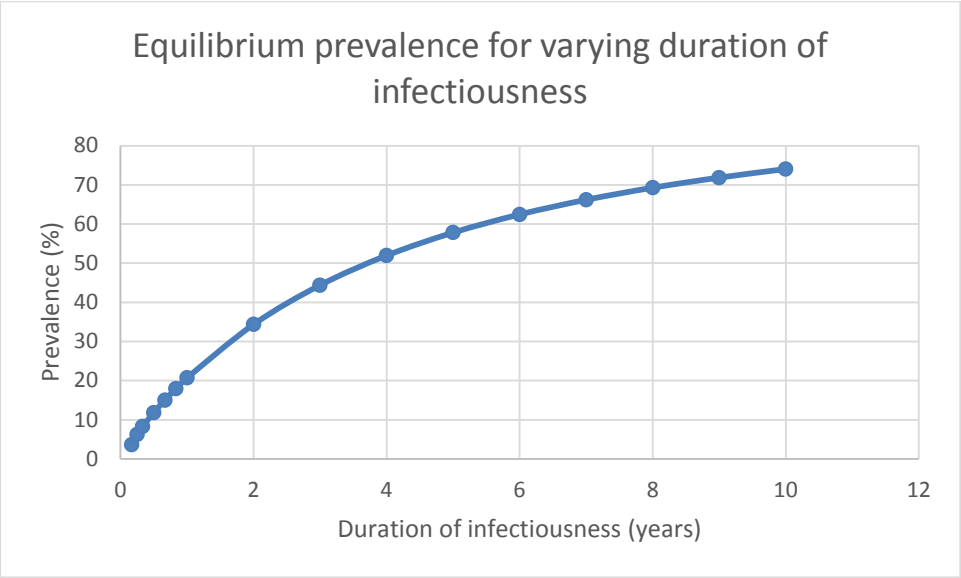
- What is the influence of epsilon on the speed with which the epidemic spreads?
  - fully assortative mixing allows peak prevalence to be reached fastest (less than a year). This is because infection is being 'trapped' in the high risk group.
  - however, above an epsilon value of 0.2, the speed of spread decreases as epsilon increases towards random mixing (reflecting the extent to which high and low activity individuals can form partnerships with each other).

If high activity individuals are more likely to have sex with high activity individuals, it can speed up the rate of spread of infection (as illustrated by q3), but also limit how far through the population infection will spread, depending on the recovery rate (as illustrated by q2).

Part 4:

Exercise 4

Duration of infectiousness (years)	Recovery rate (per year)	Equilibrium prevalence (%)
0.167	6.000	3.63
0.250	4.000	6.22
0.333	3.000	8.29
0.500	2.000	11.8
0.667	1.500	15.0
0.833	1.200	18.0
1.000	1.000	20.7
2.000	0.500	34.4
3.000	0.330	44.4
4.000	0.250	52.0
5.000	0.200	57.8
6.000	0.167	62.4
7.000	0.143	66.2
8.000	0.125	69.3
9.000	0.111	71.9
10.000	0.100	74.0



- What is the influence of the duration of infectiousness on equilibrium prevalence?
  - equilibrium prevalence increases with increasing duration of infectiousness

If individuals are infectious for longer, more transmission occurs (all else being equal), because there is a higher probability of infecting someone before you recover and thus a higher equilibrium prevalence. A longer duration of infectiousness means that 'D' is bigger, therefore R_0 is larger (recall $R_0=\beta.c.D$), therefore equilibrium prevalence is higher because equilibrium prevalence can be expressed as $1 - 1/R_0$.

Conversely, with a short duration of infectiousness, those infected are infectious for less time, which lowers the basic reproductive rate and therefore reduces the level of equilibrium prevalence.