In this part of the exercise, we will use a model which has been set up for you to explore how the amount of contact between individuals and the duration of infectiousness affects tuberculosis incidence.

**Introduction to the model**

The general structure of the model is shown below. So that we just focus on the key parameters in the model and how they influence the TB incidence, the model is not stratified by age.

[CREATE MODEL SCHEMATIC]

2. Spend a few minutes familiarizing yourself with the content of the R code. It has several sections:

1. The input model parameters (demography, natural history, and treatment-related)
2. Equations for each compartment in the model
3. The numbers of individuals in each compartment at the beginning (the ‘initial state values’)
4. Code to plot results
5. Code to print results from final time step in model

3. Run the model, plot the results, and view the final values of compartments by selecting and running all the code. You should now see a figure on the right plotting the number in each compartment over time.

**Factors influencing tuberculosis incidence – contact between individuals**

We will now explore how the amount of contact between individuals influences the epidemiology of TB in the population. The model includes a parameter, called the effective contact rate (referred to as “beta” in the model) for the number of individuals effectively contacted by each case per year. An effective contact is defined as one that is sufficient to lead to infection if it occurs between an uninfected and a smear-positive case. It is currently set to be 0.45 per year, equivalent to a contact rate of 15 contacts per year \* 0.03 probability of infection per contact.

*Q1. What do you think will happen to the following statistics if you reduce the number of individuals effectively contacted by each case:*

*a) The tuberculosis incidence?*

*b) The tuberculosis mortality?*

*c) The risk of infection?*

1. Check your hypotheses by changing the value for the effective contact rate from 0.45 to 0.30 (equivalent to a reduction in contacts from 15 per year to 10 per year) and recording your findings for this value in the table below. Repeat this for an effective contact rate of 0.15 per year (equivalent to a reduction in contacts from 10 per year to 5 per year). *Approximate answers are sufficient for this exercise.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Effective contact rate per year** | **Annual TB incidence per 100,000** | **Annual TB mortality rate per 100,000** | **Annual risk of infection (%)** |
| 0.45 (default) | 191.7 | 47.2 | 12.5% |
| 0.30 | 184.0 | 46.1 | 8.1% |
| 0.15 | 176.5 | 45.0 | 4.0% |

2. The following table summarizes the impact of reducing the effective contact rate on the above statistics. Using a calculator or a spreadsheet, use the results from the previous step to complete the table by calculating the percentage reduction in each output statistic for each reduction in the effective contact rate. *Note that the values you obtain depend on whether you use rounded or unrounded values from the previous step. The values already entered use unrounded values.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Assumed reduction in the effective contact rate** | **% reduction:** | | |
| **Annual TB incidence per 100,000** | **Annual TB mortality rate per 100,000** | **Annual risk of infection (%)** |
| 33% (15→10 per year) | 4.0% | 2.3% | 35% |
| 66% (15→5 per year) | 7.9% | 4.7% | 68% |

*Q2. Based on your results, is the effective contact rate an important factor influencing tuberculosis incidence, mortality rate and the risk of infection?*

*Q3.* ***(optional)*** *What other infection or disease-related parameters in the model will also influence these statistics? N.B. Please do not change these statistics yet – you can do this later in the session if there is time.*

**Factors influencing tuberculosis incidence – treatment initiation rate and duration of infectiousness**

We will now explore the effect of the duration of infectiousness on tuberculosis incidence. Individuals with TB in the model can die, recover naturally, or be diagnosed and successfully treated. How quickly these things happen determines the length of time an individual remains infectious.

Before continuing, **change the effective contact rate back to its default value (0.45 per year)**.

*Q5. What do you think will happen to the following statistics if you increase the rate of treatment initiation, effectively reducing time infectious, on each of the following:*

*a) The tuberculosis incidence?*

*b) The tuberculosis mortality?*

*c) The annual risk of infection?*

1. Check your hypotheses by changing the value for the rate of treatment initiation from 0.8 per year (~ 5.4 week infectious period) to 0.85 per year (~ 5.1 week infectious period), and recording your findings for these statistics in the table below. Repeat this step for a treatment initiation rate of 0.90 per year (~4.8 week infectious period):

|  |  |  |  |
| --- | --- | --- | --- |
| **Average rate of treatment initiation** | **Annual TB incidence per 100,000** | **Annual TB mortality rate per 100,000** | **Annual risk of infection (%)** |
| 0.8 per year (default) | 191.7 | 47.2 | 12.5% |
| 0.85 per year | 190.6 | 44.5 | 11.7% |
| 0.9 per year | 189.6 | 42.1 | 11.1% |

2. Using a calculator or a spreadsheet, use the results from the previous step to complete the table by calculating the percentage reduction in each output statistic for each reduction in the average duration of infectiousness for smear-positive cases. *Note that the values you obtain depend on whether you use rounded or unrounded values from the previous step. The values already entered use unrounded values.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Increase in the average rate of treatment initiation** | **% reduction:** | | |
| **Annual TB incidence per 100,000** | **Annual TB mortality rate per 100,000** | **Annual risk of infection (%)** |
| 6.25% (0.8→0.85) | -0.6% | -5.7% | -6.4% |
| 12.5% (0.8→0.90) | -1.1% | -10.8% | -11.2% |

*Q6. Based on this table, is the average rate of treatment initiation (and, thereby, duration of infectiousness) an important factor influencing tuberculosis incidence, mortality rate and the risk of infection?*

**Appendix A**

Duration of infectiousness and rate of treatment initiation – how to calculate