Practicals: An introduction to TB modelling

Aims

- To illustrate questions which might be addressed using mathematical models
- To give you insight into what data and assumptions models might need

Practical 2: Modelling the impact and cost effectiveness of TB interventions

Objectives

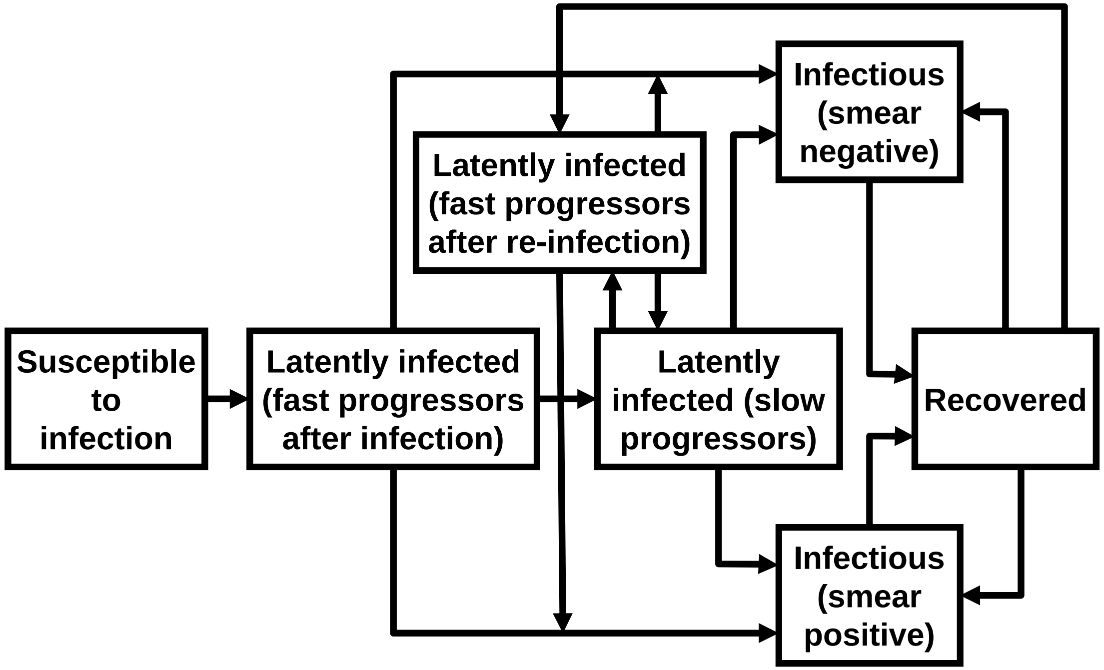
By the end of this practical, you should:

- Know how you might estimate the impact of improved diagnostics.
- Describe and interpret different measures of cost-effectiveness

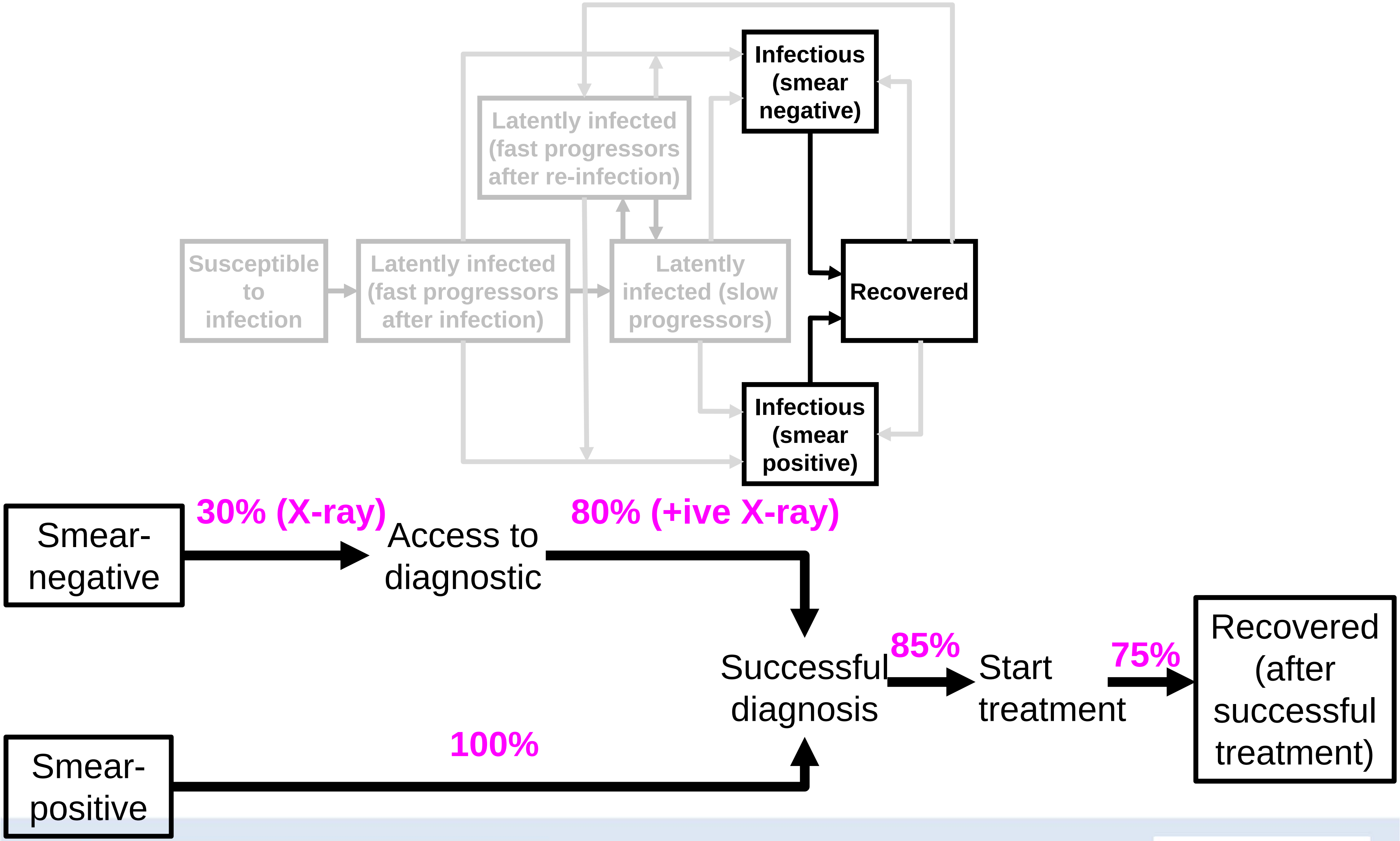
Overview

- Quick introduction to the model
- Exploring the impact of improved diagnostics on the number of cases prevented
- Calculating the cost and cost-effectiveness of introducing the new diagnostic

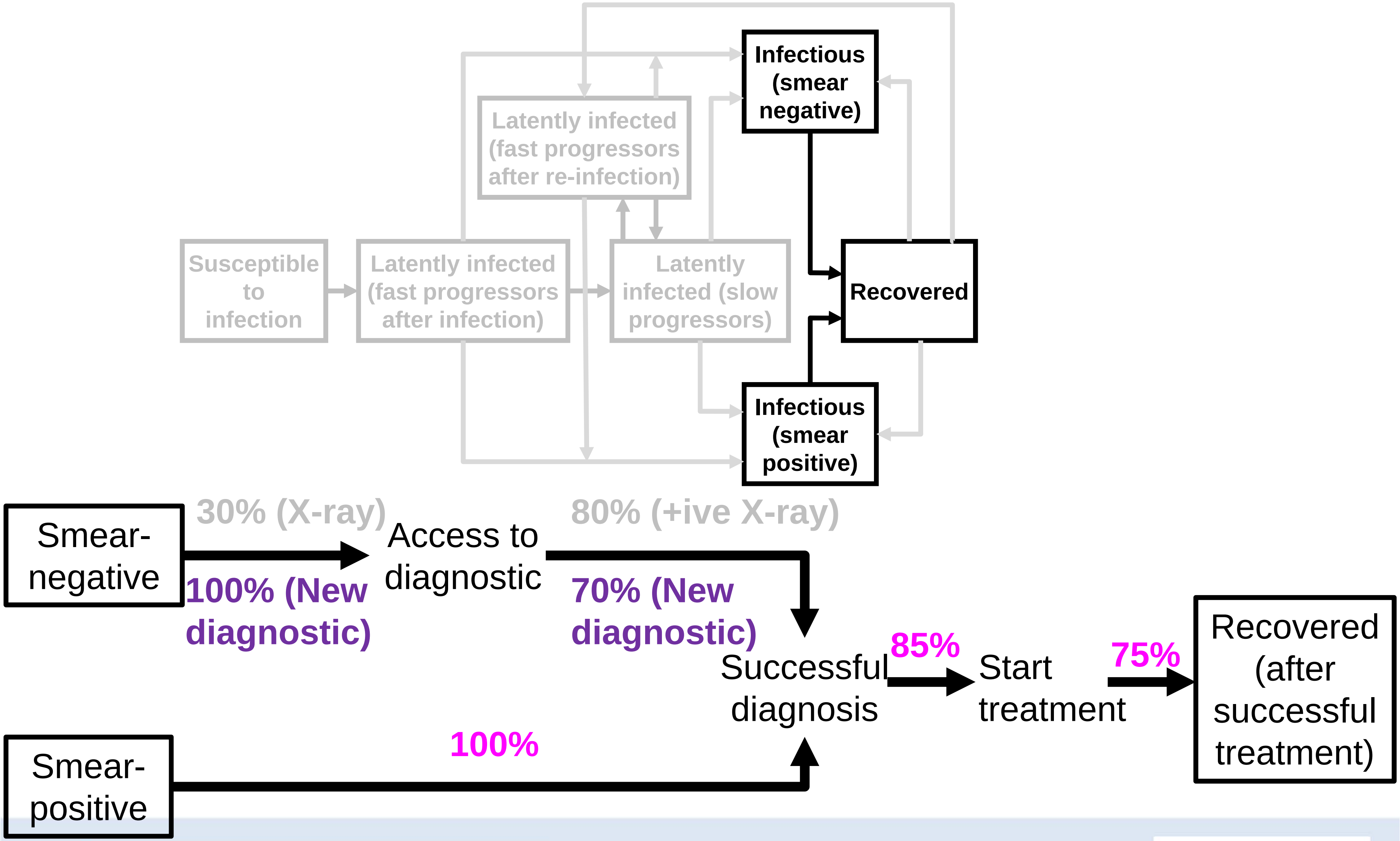
General structure of the model



Assumed pre-existing diagnostic pathway



The pre-existing and new diagnostic pathways



TB Modelling and Analysis Consortium

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Answers

Q1 **Short term** – small impact expected, as the intervention does not directly prevent cases (only leads to increased diagnosis.

Long term – an increased impact is expected due to the indirect effect of improved diagnostics, i.e. ↓ in the duration of infectiousness, leading ↓ in number of infections (and cases) generated by each case.

Answers

Step 1, page 4

	Without the intervention	With the intervention	
		End of 2014 (1 year)	End of 2023 (10 years)
TB incidence per 100,000 per year	197	197	184
TB mortality rate per 100,000 per year	51	47	42
Annual risk of infection (%/year)	2.4	2.4	2.2

Answers

Step 2&3, page 4

	Without the improved diagnostic	With the improved diagnostic
Total number of TB cases in 2014	193	192

Number of cases prevented by introducing the new diagnostic in 2014 = 193-192 = 1

Q2. Over a 10 year period, might expect to prevent at least 10×number of cases prevented over 1 year = 10 cases

Answers

Step 1, page 4

	Without the improved diagnostic	**With the improved diagnostic**
Total number of TB cases in 10 years	1969	1906

Number of cases prevented over 10 years by introducing the new diagnostic in 2014 = 1969-1906 = 63

Answers

Q3. Number of cases predicted over a 10 year period is much greater than 10×number of cases prevented over 1 year.

This is due to the indirect effect of improved diagnostics:

↓ in the duration of infectiousness leads to:

↓ in the number of infections generated by each case;

↓ in the risk of infection;

↓ in the number of individuals at risk of progression to disease

Answers

Q4 (optional). If the effective contact rate is very high (20/year), the intervention prevents 98 cases.
i.e. higher than when the effective contact rate is 15 *per year.*

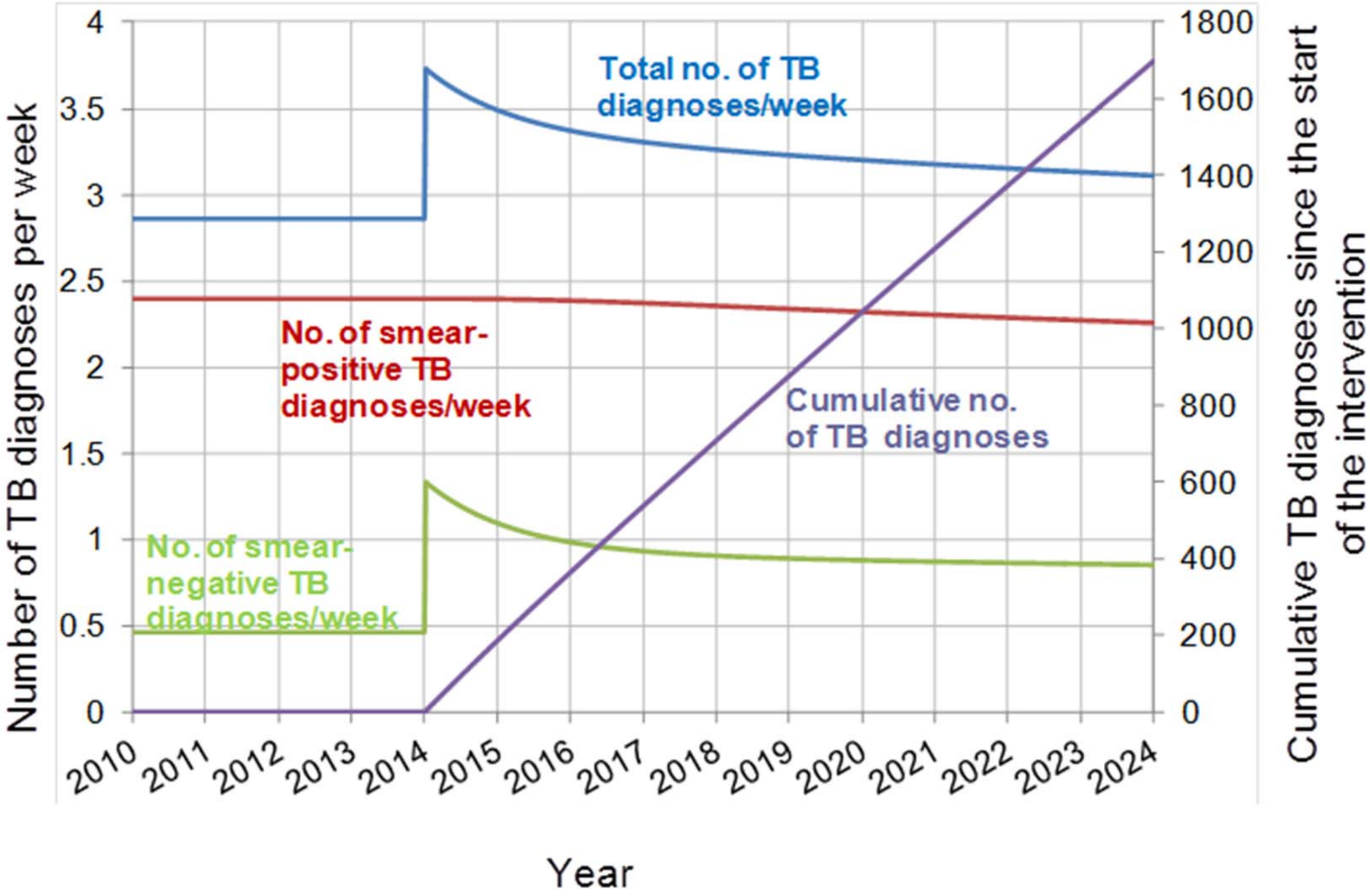
This is due to the *increased* background incidence

Answers

Q5. Introduction of new test leads to:

- ↑ in the number of diagnoses in smear-negatives.
  - This is due to the increased number of cases being detected because of the increased sensitivity of the test vs X-ray
- As TB incidence ↓, the number of diagnoses in smear-negative cases also falls.
- ↓ incidence of smear-positive TB, because of the reduction in the number of new infections (and cases) resulting from each infectious case

Graph 3: The number of TB diagnoses per week following the introduction of the new diagnostic in 2014.



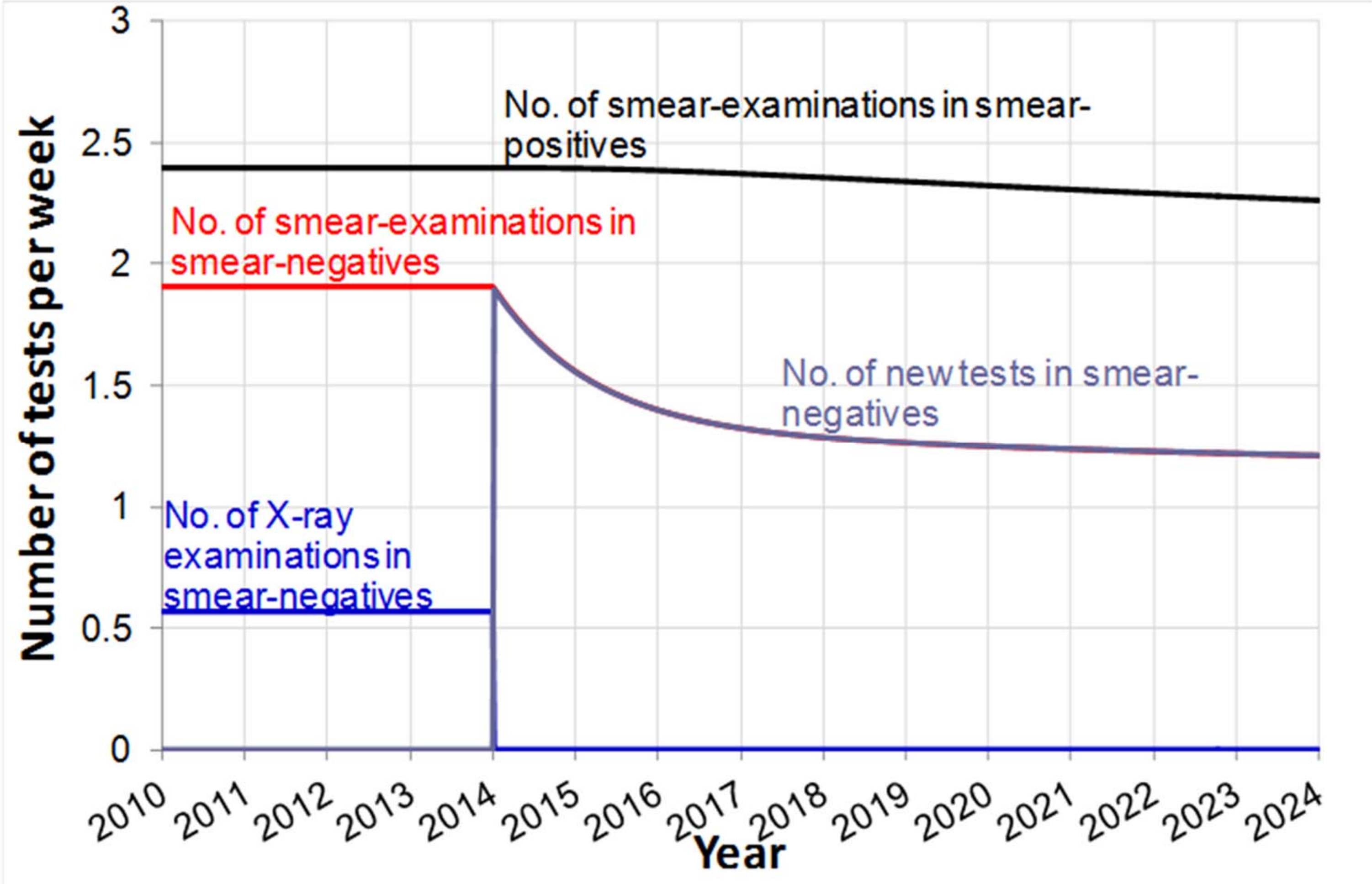
Answers

Step 1, page 5

After the new diagnostic is introduced:

- No examinations are carried out using X-ray
- The new diagnostic is offered to all smear-negative cases (vs 30% of cases being offered X-ray before the intervention)
  - Therefore, the number of new diagnostic tests used equals the number of smear examinations in smear-negative cases.
- Over time, the numbers of all tests used in the new algorithm declines as the TB incidence ↓.

Graph 4: Predictions of the weekly numbers of smear examinations and tests



Answers

Q6. The cost associated with the intervention is much greater than the cost of continuing with the current diagnostic algorithm ($249,256 compared to $86,423).

The increased cost is a consequence of:

- Higher cost of the new test compared to X-ray ($20 vs $10)
- Increased proportion of smear-negative cases offered the new test compared X-ray (100% vs 30%).

Answers

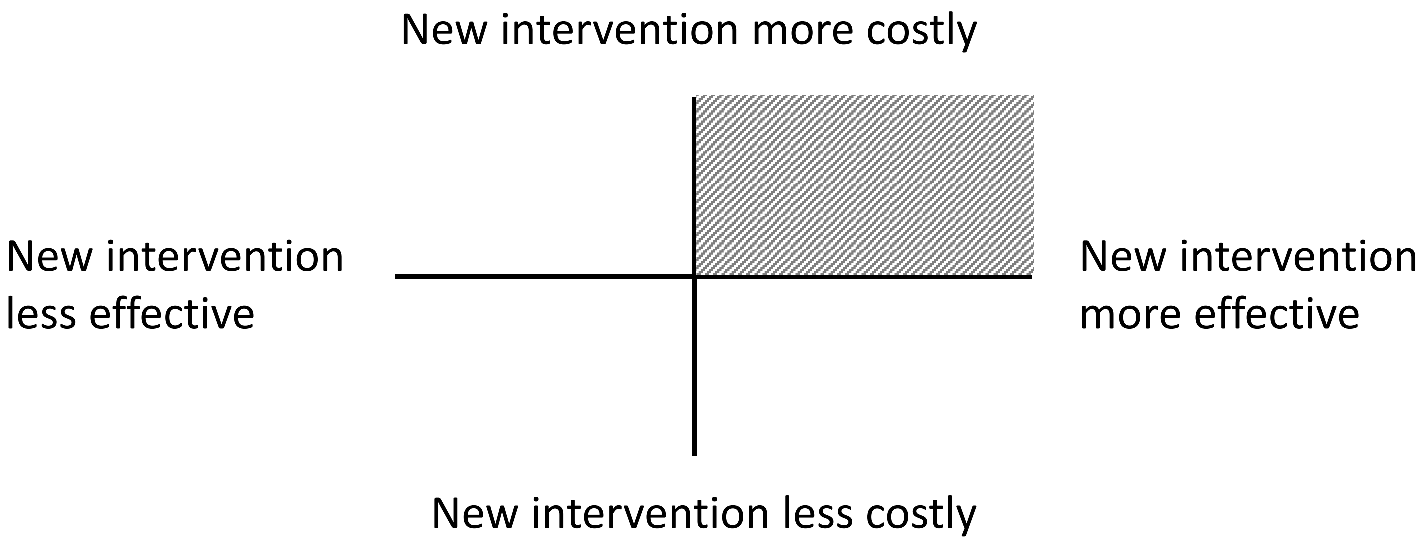
Q7a). The average cost effectiveness ratio (ACER) is:

Total cost of intervention/Total impact of intervention

The ACER of the current algorithm = $58/case
The ACER of the new diagnostic test = $147/case

Answers

Q7b). The new intervention lies in the upper right corner of the cost effectiveness plane



It is more effective than the current algorithm <u>but</u> costs more per case diagnosed

Answers

Q7c). To assess which intervention was most cost-effective you would need to know:

What are the health impacts of diagnosing more cases?

What is the “willingness to pay” threshold?

Answers

Q8 (optional). If the population was larger the cost per diagnosis would be lower:

- ↑ in the population leads to ↑ number of cases
- Fixed costs associated with the new test are divided between more individuals
- Cost per diagnosed case ↓

Answers

Q9 (optional). Discounting means intervention impacts which occur in the future are worth less than those that occur sooner i.e:

Case averted in 10 years time is worth much less than a case averted tomorrow

If discounting of impacts was included:

- Impact of intervention ↓
- Cost of intervention remains the same
- ACER of the new diagnostic test ↑

Practical 2: Modelling the impact and cost effectiveness of TB interventions

Objectives

By now, you should hopefully:

- Have a conceptual understanding of how you might incorporate interventions into a mathematical model for TB.
- Know how you might estimate the impact of improved diagnostics.
- Be able to describe and interpret different measures of cost-effectiveness

Practicals: An introduction to TB modelling

Having done the two practicals, you should now:

- Be aware of questions which might be addressed using mathematical models

- Have insight into what data and assumptions models might need…