

Decision analytic models for tests – decision trees

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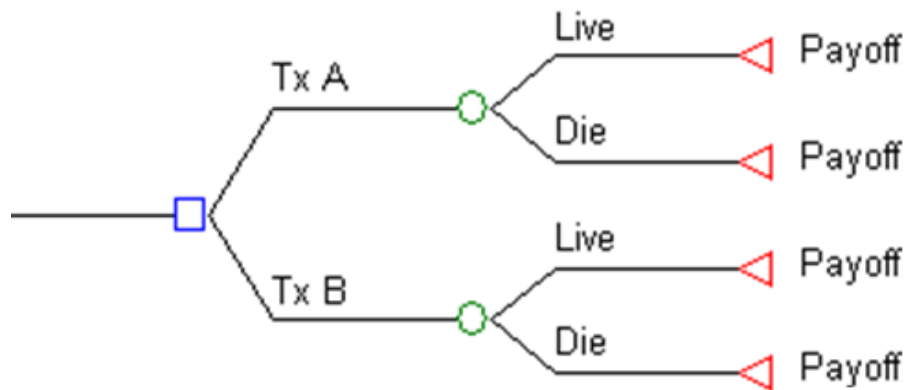
Learning Objectives

Diagnostic accuracy measures, together with prevalence, can be used within **decision tree models** to model intermediate outcomes




An example decision tree model is provided to illustrate the key concepts

Decision Tree models

- A decision tree utilizes a flow diagram to show the logical structure of the problem



- Think of time flowing from left to right, with each of the branches depicting the possible patient pathways, contingent on particular events.

-  **Decision nodes** – the square nodes represent a **choice** for the decision maker.
-  **Chance nodes** – circular nodes represent **uncertain events**, with the branches coming off chance nodes indicating all the possibilities that may occur. Each of these chance events has an associated probability and these should sum to 1.0 (100%) for all events coming off a particular chance node.
-  **Terminal nodes** – triangular nodes represent the **endpoint** of the model and are assigned value(s) or *payoff(s)*. These payoffs can be utility, costs, or anything else thought to be an important outcome.

Decision Tree models

1. Formulate the decision tree structure
2. Assign event probabilities
3. Assign effects (e.g. QALYs)
4. Assign costs
5. Weight costs and effects by pathway probabilities
6. Calculate ICER

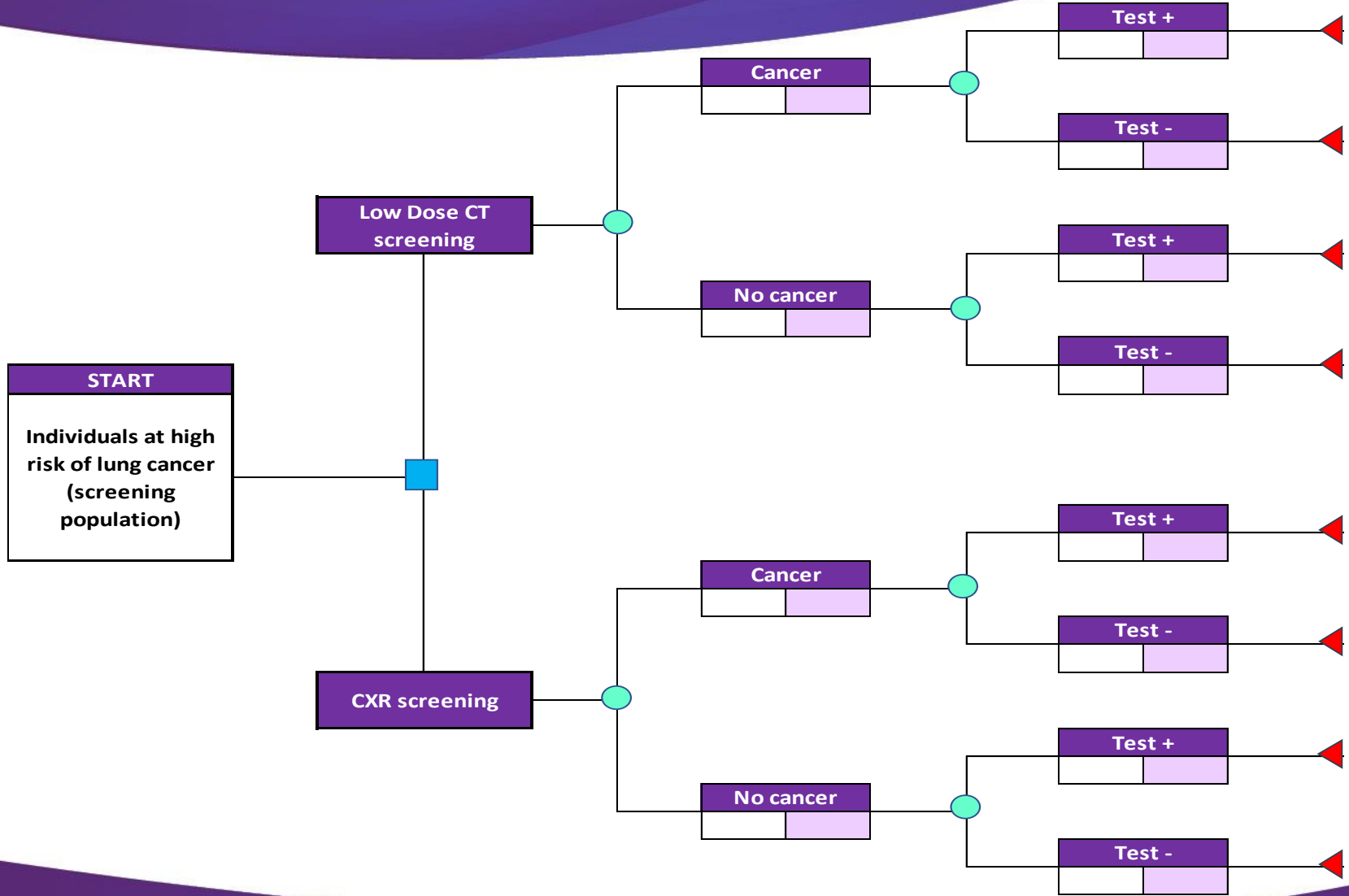
Simple test example – Low dose CT vs. Chest X-Ray for lung cancer screening*

1. Formulate the decision tree structure

*Note that this is an example model intended for teaching purposes only – it is not intended to inform clinical practice

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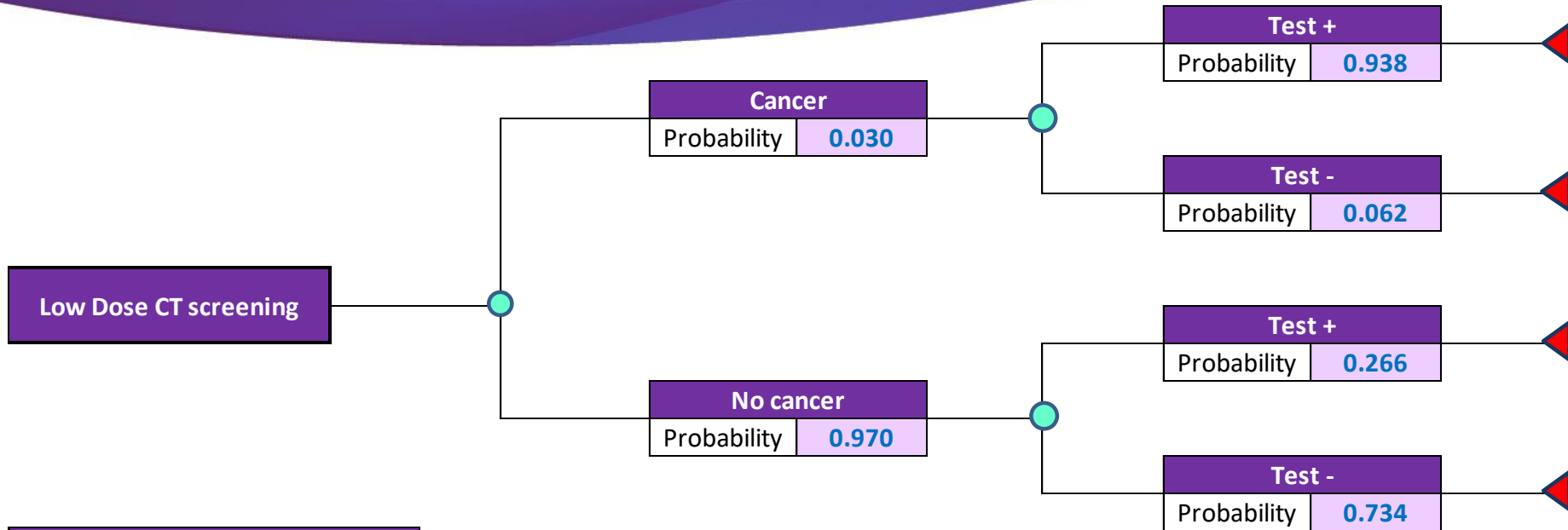


Simple test example – Low dose CT vs. Chest X-Ray for lung cancer screening

1. Formulate the decision tree structure
2. **Assign event probabilities**

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Test data	
Prevalence	3.0%
LDCT Sensitivity	93.8%
LDCT Specificity	73.4%

- Prevalence used to set proportion with/ without cancer
- LDCT sensitivity used to set proportion Test +/ Test- in the cancer group
- LDCT specificity used to set proportion Test +/- in the no cancer group

Decision Tree models

1. Formulate the decision tree structure
2. Assign event probabilities
- 3. Assign effects (e.g. QALYs)**
- 4. Assign costs**

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5-year QALY data	
Treated cancer	3.50
Missed cancer	1.70
No cancer, correctly not referred	4.50
No cancer, incorrectly referred	4.48

- For QALYs, assign relevant QALY value to each model branch (e.g. for the top branch, [Cancer, Test+], the relevant QALY value is 'Treated cancer' (3.50))

Cost data	
LDCT	\$139
CXR	\$31
Referral	\$700
Cancer treatment (average 5 year cost)	\$25,200
Missed cancer (average 5 year cost)*	\$56,560

- For costs, add up all the costs that occur along the given branch (e.g. for the top branch, the cost consists of LDCT + Referral + Cancer treatment = \$139 + \$700 + \$25,200 = \$26,039)

Note that we've taken a shortcut here...

- 5-year cost and QALYs have been “bolted on” to the TP/ TN/ FP/ FN branches
- Often this kind of data may not be available
- In that case, long term outcomes would need to be modelled, e.g. using a Markov Model

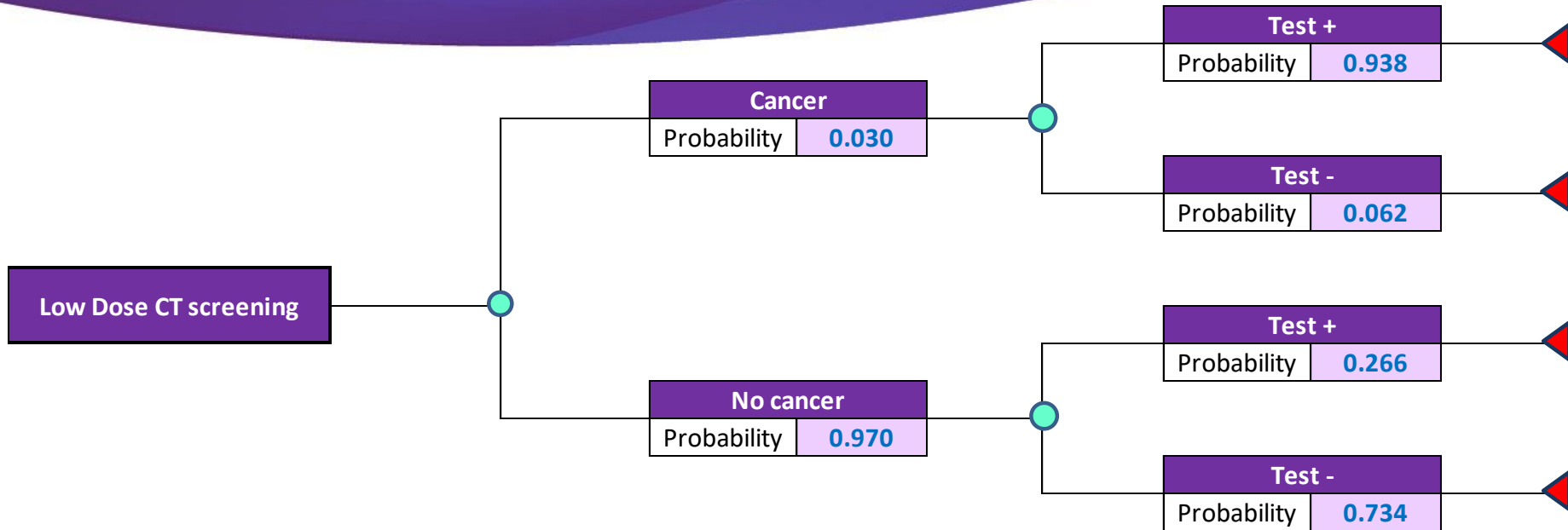
(see Dr Beth Shinkin's session on this)

Decision Tree models

1. Formulate the decision tree structure
2. Assign event probabilities
3. Assign effects (e.g. QALYs)
4. Assign costs
5. **Weight costs and effects by pathway probabilities**

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- The full **pathway probabilities** for a given branch of the tree are calculated by multiplying through by the individual event probabilities
- E.g. For the top pathway, the pathway probability is: $0.030 \times 0.938 = 0.028$
- I.e. there is a 2.8% probability that patients have cancer and get a positive test result

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RESULTS TABLE					
Pathway	Pathway probability	Pathway Cost	Pathway QALYs	Weighted cost [pathway cost*probabiliy]	Weighted QALYs [pathway QALYs*probability]
TP appropriate referral	0.028	\$26,039	3.5	\$733	0.10
FN missed cancer	0.002	\$56,699	1.7	\$105	0.00
FP inappropriate referral	0.258	\$839	4.48	\$216	1.16
TN appropriately not referred	0.712	\$139	4.5	\$99	3.20
LDCT strategy TOTALs	1.000	-	-	\$1,154	4.46

Decision Tree models

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Strategy	Total cost	Total QALYs	Incremental cost	Incremental QALY	ICER
Chest XR	\$1,031	4.46	-	-	-
LDCT	\$1,154	4.46	\$123	0.00395	\$31,090

- $ICER = \frac{\text{Incremental cost}}{\text{Incremental QALY}}$



Always check the direction of cost and QALY increments!
Your ICER may not be saying what you think it is saying

Decision Tree models

Strengths

- Easy to interpret (intuitive visual flow of events)
- Relatively simple to develop

Limitations

- Time not explicitly accounted for
- Become unwieldy when dealing with reoccurring events (e.g. chronic diseases) or complex pathways
- Model structure cannot easily be updated/altered

Example

In your own time...

Open the Excel file called '[Decision Tree Model](#)'.

The first worksheet provides the model parameters, model, and results tables. Make sure you understand how the model parameters feed into the model, and how the model results are calculated.

Have a go at the questions provided in the second worksheet. What happens if the prevalence, sensitivity or specificity values change?

Summary

- Diagnostic accuracy and prevalence data can be used to construct simple decision tree models
- Together with cost and QALY data, cost-effectiveness results can be produced
- Long term outcomes can also be modelled by linking the intermediate diagnostic outcomes to long term treatment outcomes using a Markov model [more on this later...]