For the purposes of this exercise, assume that ten per cent of patients with Non Hodgkins lymphoma have a newly discovered variant of the disease that is associated with a life expectancy of five years. Patients with the standard form of Non Hodgkins lymphoma have a life expectancy of seven years. A new drug prolongs life for patients with the variant form of disease from five to six years, but it has no effect on patients with the standard form of disease. The drug costs $10,000 for a course of treatment. It has negligible side effects. A diagnostic test distinguishes patients with the variant form from those with the standard form of the disease. The test costs $200. It has a sensitivity of 0.70 and a specificity of 0.80 for detecting the variant form of the disease. Costs are discounted, and years of life are discounted and have been quality adjusted (so they are QALYs).

You are the medical director of a large HMO, and the CEO has asked you to develop a policy for using the new drug for treating patients with Non Hodgkins lymphoma. A lawyer representing the families of patients with Non Hodgkins lymphoma in your HMO argues that all Non Hodgkins lymphoma patients should be given drug treatment because the diagnostic test misses too many people with the variant form of the disease. Your consulting group of clinical experts recommends that treatment be given only to patients with a positive test result. They note that the treatment is expensive and most patients will not benefit if it is given to every patient. The marketing director of your HMO tells you that no one should get the drug. He points out that many positive test results will be falsely positive, that patients with a false-positive test result will not benefit from the drug, and that the cost of providing the drug to patients with a positive test result will force the company either to withhold other treatments from other patients or to raise premiums, which would reduce the company's market share.

**Question 1.** Draw a decision tree that describes the problem. Include all the information that an analyst would need to investigate the problem.

**Question 2.** Calculate the expected cost of each choice in the decision tree.

**Question 3.** Calculate the expected number of years of life associated with each choice in the decision tree.

**Question 4.** Calculate the policy-relevant cost-effectiveness ratios of the choices in the decision tree.

**Question 5.** Which policy would you recommend? Why?

Answers start on the next page.
**Question 1.** Draw a decision tree that describes the problem. Include all the information that an analyst would need to investigate the problem.

```
Choose

Treat everyone

Patients with new form of disease
Prevalence
10000 / 6
Other patients
10000 / 7
1 - prevalence

Patients with new form of disease
Prevalence
(200 + 10000) / 6
True positive
Sensitivity
False negative
1 - sensitivity
200 / 5

Other patients
1 - prevalence

Patients with new form of disease
Prevalence
(200 + 10000) / 7
True negative
Specificity
200 / 7

Choose

Test, treat positives

Patients with new form of disease
Prevalence
0 / 5
Other patients
0 / 7
1 - prevalence

Don't treat anyone

Patients with new form of disease
Prevalence
0 / 5
Other patients
0 / 7
1 - prevalence
```

Where: Prevalence = 0.10, Sensitivity = 0.70, and Specificity = 0.80.

The alternative decision tree on the next page also can be used to answer these questions. This tree differs from the original tree only in the middle branch from the choice node. Many clinicians will prefer the logic of the alternative tree, because it describes the way they think when managing patients. The alternative tree, however, has a significant disadvantage. It is more difficult to solve because its probability expressions are more complicated, if one starts with only the sensitivity, specificity, and prevalence, which is the usual case. The probability expressions for the two branches from the node "Test, treat positives" describe the probability of having a positive test result (true positives + false positives) and the probability of having a negative test result (true negatives + false negatives). These probability expressions are more complicated than those required in the original tree.

The probability expressions for the subsequent four branches are much more complicated than those required in the original tree. The probability expression for the upper branch coming from the node "Result positive" describes the probability of having disease when the test result is positive. Note that it is the Bayes' Theorem formulation of the positive predictive value (true positives divided by true positives plus false positives). The probability expression for the lower branch is one minus this value. The probability expression for the upper branch coming from the node "Result negative" describes the probability of not having disease when the test result is negative. Note that it is the Bayes' Theorem formulation of the negative predictive value (true negatives divided by true negatives plus false negatives). The probability expression for the lower branch is one minus this value. Although the alternative tree is more difficult to work with than the original tree, it provides answers that are identical to those provided by the original tree.
**Question 2.** Calculate the expected cost of each choice in the decision tree.

The expected costs for the 3 choices are: $0 for the choice "don't treat anyone," $2,700 for the choice "test, treat positives," and $10,000 for the choice "treat everyone."

**Question 3.** Calculate the expected life expectancy of each choice in the decision tree.

The expected life expectancies for the 3 choices are: 6.800 years for the choice "don't treat anyone," 6.870 years for the choice "test, treat positives," and 6.900 years for the choice "treat everyone."

**Question 4.** Calculate the policy-relevant cost-effectiveness ratios of the choices in the decision tree.

The calculations from question 2 provide the 3 numbers in the second column in the table below. The calculations from question 3 provide the 3 numbers in the third column in the table below.
<table>
<thead>
<tr>
<th>Choice</th>
<th>Expected Cost in Dollars</th>
<th>Expected Survival in QALYs</th>
<th>Incremental Cost in Dollars</th>
<th>Incremental Survival in QALYs</th>
<th>Incremental Cost-Effectiveness Ratio in Dollars/QALY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don't treat anyone</td>
<td>0</td>
<td>6.800</td>
<td>---------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Test, treat positives</td>
<td>2,700</td>
<td>6.870</td>
<td>2,700</td>
<td>0.070</td>
<td>38,571</td>
</tr>
<tr>
<td>Treat everyone</td>
<td>10,000</td>
<td>6.900</td>
<td>7,300</td>
<td>0.030</td>
<td>243,333</td>
</tr>
</tbody>
</table>

To identify the appropriate cost-effectiveness ratio, first, order the choices according to either increasing values for outcome or increasing values for cost (both options lead to the same order in this case). Second, eliminate therapies with both a higher cost and a less valuable outcome than at least one alternative (there are none here). Third, compute incremental cost-effectiveness ratios for each adjacent pair of outcomes. (The incremental cost is the expected cost of one choice minus the expected cost of an adjacent choice. The incremental life expectancy is the expected years of life with one choice minus the expected years of life with an adjacent choice. The incremental cost-effectiveness ratio is the incremental cost divided by the incremental life expectancy.) Fourth, eliminate choices that have a lower effectiveness but a higher cost-effectiveness ratio than an alternative choice (none here). Fifth, recalculate the incremental cost-effectiveness ratios (not necessary). Sixth, select the ratio with the highest acceptable incremental cost-effectiveness ratio. If the cutoff is $50,000 to $100,000, then the "test, treat positives" choice has the highest acceptable incremental cost-effectiveness ratio. The reasons for each step in this process will be explained during class.

**Question 5.** Which policy would you recommend? Why?

Many analysts would recommend that all Non Hodgkins lymphoma patients be tested and those with positive test results be treated. This choice is preferred over the choice not to treat anyone because the additional amount that has to be spent to save a year of life through testing is less than what we currently spend on many other interventions. The choice for testing is preferred over the choice to treat everyone, because the additional amount that has to be spent to save a year of life by treating everyone is higher than what we currently spend on most other interventions.