Value of Information to Inform Decision Making Under Uncertainty
VALUE OF INFORMATION TO INFORM DECISION MAKING UNDER UNCERTAINTY

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Applications for Value of Information

• Prioritize where additional investment will lead to maximal benefits
• Identify research areas with the greatest likelihood of influencing clinical practice and patient outcomes
• Quantify the expected opportunity loss from decision making under uncertainty by estimating the value of obtaining additional information through research
Based on Bayes Rule: $P(A|B) = \frac{P(B|A)P(A)}{P(B)}$

Traditional hypothesis testing (e.g., clinical trial) gives you $p(data|hypothesis)$ but what you want is $p(hypothesis|data)$

There is a 90% chance that the net benefit of protocol a exceeds that of protocol b

$p(expected\ benefit\ of\ future\ study|existing\ clinical\ trial\ data)$
• Goal is to make the decision offering the greatest net benefit given constraints
• There is uncertainty in the inputs to the decision
• Expected cost of uncertainty is determined by the probability that a decision based on existing information will be wrong and the consequences if the wrong decision is made
• Expected value of (im)perfect information
The estimated mean net benefit of the new technology/drug/intervention
The amount and results of existing data
The value placed on opportunity losses when they occur
The size of the patient population who could benefit from the new technology/drug/intervention

Expected Value of Information is determined by:
EVPI = \( E\{\max_a \text{NMB}(a,s)\} - \max_a \{\text{NMB}(a,s)\} \)

- where \( E\{\max_a \text{NMB}(a,s)\} \) represents the expected net monetary benefits under perfect information
- \( \max_a E\{\text{NMB}(a,s)\} \) represents the expected net monetary benefits under prior information
- Assess the optimal action for all possible values of \( s \) and then determine the weighted average of the resulting values over the prior belief about the likelihood of each event
Costs and Benefits of the Decision

• Benefits described in terms of utilities, QALYs, DALYs
• $/QALY or other cost-effectiveness ratios
• Predicted costs as compared to monetized benefits
• Number of patients impacted is essential for population VOI
Example Decision Tree

<table>
<thead>
<tr>
<th>Standard Care</th>
<th>Quality</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_C$</td>
<td>$C_E$</td>
</tr>
<tr>
<td></td>
<td>$1 - P_C$</td>
<td></td>
</tr>
<tr>
<td>New Treatment</td>
<td>$P_T$</td>
<td>$C_T + C_{SE} + C_E$</td>
</tr>
<tr>
<td></td>
<td>$1 - P_T$</td>
<td></td>
</tr>
<tr>
<td>$P_{SE}$</td>
<td>$[L(1 + Q_E)/2] - Q_{SE}$</td>
<td>$C_T + C_{SE}$</td>
</tr>
<tr>
<td></td>
<td>$1 - P_{SE}$</td>
<td></td>
</tr>
<tr>
<td>$P_T$</td>
<td>$L - Q_{SE}$</td>
<td>$C_T + C_E$</td>
</tr>
<tr>
<td></td>
<td>$1 - P_T$</td>
<td>$C_T$</td>
</tr>
<tr>
<td></td>
<td>$L$</td>
<td>$C_T$</td>
</tr>
</tbody>
</table>

$Q$ and $P$ are probabilities of certain events, and $L$ is a constant.
• What would it be worth to conduct an observational study on $n = 60$ patients who are on the new treatment?
• EVSI = $5,550$ per patient; compare to cost
• What would be the EVSI for a study allocating $nT = 200$ patients to new treatment and another $nC = 200$ to standard care?
• EVSI = $3,260$ per patient
Conclusions

• Value of information techniques are used to evaluate research priorities based on reducing uncertainty

• Builds on existing cost-effectiveness studies using Bayesian statistics

• No “off the shelf” software – requires linking models, software platforms
Further Reading


• Andronis et al. 2015 A Practical Application of Value of Information and Prospective Payback of Research to Prioritize Evaluative Research, *Medical Decision Making*, DOI: 10.1177/0272989X15594369