Improving Healthcare with Simulation Workshops

Simulation for Health
Economic Analysis
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- Audio

- Q and A

- Recording available at
  www.SIMUL8.com/improving_healthcare
Health Economic Modeling

Advantages of Discrete-Event Simulation

Real World SIMUL8 Model

Questions

References
The International Society for Pharmacoeconomics and Outcomes Research (ISPOR) Task Force on Good Research Practices - Modeling Studies:

"[...] an analytic methodology that accounts for events over time and across populations, that is based on data drawn from primary and/or secondary sources, and whose purpose is to estimate the effects of an intervention on valued health consequences and costs."¹
The aim of health economic modeling is to generate expected values for the clinical and economic effects of therapeutic alternatives.
There are two quite distinct aspects of model-based economic evaluation

1. First, it is necessary to produce the mean estimate of cost-effectiveness (or other outcome measures) for a given set of parameters (Type of Model)

2. Second is the issue of exploring the effects of uncertainty in the model inputs (Sensitivity Analysis)
Decision Trees

Patient or Population

- Treat
  - Response \( p_1 \)
  - No Response \( 1-p_1 \)

- Wait and see
  - Response \( p_2 \)
    - No Response \( 1-p_2 \)

- No Treat
  - Response \( p_3 \)
  - No Response \( 1-p_3 \)

Consequences

- ER
- LE
- QALY
- C
Health Economic Modeling

- **Cohort or Individual State-Transition Models**

  - Cohort models aggregate the individuals into a group which becomes the unit of analysis. Over time this group “breaks up” into pre-defined subgroups according to the events being modeled (A). Individual models consider the experience of each patient individually, even if they report results at the level of the entire population. Each individual has unique characteristics, on the basis of which their individual course is modeled (B).

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**Cohort-Based State Transition Model**

<table>
<thead>
<tr>
<th>Year</th>
<th>Well</th>
<th>Disease</th>
<th>Dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>116</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>120</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>

| Cohort | 11.6% | 23.0% | 65.4% |

**Individual-Based State Transition Model**

<table>
<thead>
<tr>
<th>Year</th>
<th>Well</th>
<th>Disease</th>
<th>Dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1000</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1</td>
<td>1012</td>
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<tr>
<td>2</td>
<td>1022</td>
<td>234</td>
<td>664</td>
</tr>
<tr>
<td>5</td>
<td>1022</td>
<td>234</td>
<td>664</td>
</tr>
</tbody>
</table>

N=1000
State Transition Models (No Interaction)
- Markov and Monte Carlo Simulation\(^2,3\)

Markov Model
Adapted from Hepatitis B Model\(^1\)

Monte Carlo Simulation
Adapted from Hepatitis B Model\(^1\)
Health Economic Modeling

- Event-Based Models (Interaction)
  - Discrete-Event Simulation (DES)

  - Discrete event simulation (DES) is a flexible modeling method characterized by the ability to represent complex behavior within, and *interactions* between individuals, populations, and their environment\(^4\)

  - Applications in health care have increased over the last 40 years\(^5\) and include biologic models\(^6,7\), process redesign and optimization\(^8\text{-}10\), geographic allocation of resources\(^11,12\), trial design\(^13,14\), and policy evaluation\(^15\text{-}17\)

  - In health economics, DES is a preferred choice as it favors greater flexibility in depicting the cost-effectiveness of prevention or therapeutic interventions for chronic disease\(^18\)
Basic Patient/Disease Pathway - Chronic Venous Leg Ulcer
Health Economic Modeling

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Our study models healing progression, decision for best clinical pathway (community, clinic, specialist etc.), time of reoccurrence for each patient/number of wounds separately, which requires a large number of attributes and events that likely exceeds the manageable size of a Markov model.

Further, the time to event (e.g. 100% healing, 75% healing, pain resolution etc.) depends on the time the patient has spent in different clinical situations (the previous attribute).

Such “memories” can be attached to the individuals in a DES model, which is difficult to achieve with a cohort Markov approach.

In a DES model, individual life histories are created by drawing randomly from distributions that describe the time to the occurrence of particular events. The individuals from the study population would move from one attribute to another, driven by events, by means of time to progression of wound severity, time to decision for hospitalization, probability of infection and death, survival time of wounds to healing, and time to death.
Advantages of Discrete-Event Simulation\textsuperscript{18-25}

- Represents clinical reality
- Presents the course of disease naturally with few restrictions
- Is flexible: no mutually exclusive branches or states required
- Follows the natural concept of time, the simulation clock keeps track of the passage of time (no fixed cycles)
- Offers flexibility handling perspectives and sensitivity analyses
- Permits transparency (eliminates the “black box”)
- Allows queuing (e.g., if a health resource is not available at a given time)
- Enables modeling of limited resources, bottlenecks, if applicable to the problem
- Defines patients as explicit elements with specific attributes (e.g., sex, age, event history) that can be modified over time
- Provides option of updating variables continuously or at specific time periods
- In economic evaluations, DES model has the flexibility to accommodate a richer structure without making it unmanageable in size
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• Please forward any topics you would like to see covered to steven.l@simul8.com

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• Continue the discussion on SIMUL8 in Health – LinkedIn Group