HEALTH ECONOMICS
RADIOTherAPy IN CERVICAL CANCER

Alfredo Polo MD, PhD

Applied Radiation Biology and Radiotherapy Section
Division of Human health
COSTS

- Direct medical costs
- Direct non-health care costs
- Changes in use of informal caregiver time
- Patient time costs

OUTCOMES

- Societal
- Patient
- Payer
COSTS
- Direct medical costs
- Direct non-health care costs
- Changes in use of informal caregiver time
- Patient time costs

OUTCOMES
- Societal
- Patient
- Payer

PERSPECTIVE
- Cost-minimization analysis
- Cost-benefit analysis
- Cost-effectiveness analysis
- Cost-utility analysis
<table>
<thead>
<tr>
<th>COST-MINIMIZATION</th>
<th>COST-BENEFIT</th>
<th>COST-EFFECTIVENESS</th>
<th>COST-UTILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The outcome of interest for the experimental treatment or intervention does not differ from the standard treatment, resulting in the intervention with the least cost being the favoured intervention.</td>
<td>• In a cost-benefit analysis, both cost and effects are valued in terms of currency.</td>
<td>• The cost (numerator) remains the same while the denominator contains the outcome or effect of interest (overall survival, disease-free survival or number of cancers prevented or detected).</td>
<td>• The cost (numerator) remains the same while but the denominator is quality-adjusted survival, which is usually measured in quality-adjusted life years (QALYs).</td>
</tr>
<tr>
<td>• It may not be “cost-effective” to perform an economic analysis of interventions that do not differ from a standard intervention or treatment.</td>
<td>• It is very difficult to value a year of life saved or a cancer prevented.</td>
<td>• The Result is a ratio with the units $/life year or $/disease-free life year.</td>
<td>• A QALY is a discounted value of health care that adjusts survival by a patient preference for the health state a patient was in at the time of the measurement.</td>
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<tr>
<td></td>
<td>• The output of the cost-benefit analysis is an unit-less ratio with a higher number being preferred.</td>
<td>• Threshold to separate cost-effective interventions is $50,000/life year.</td>
<td>• Cost-utility analyses are helpful in trying to compare nonsimilar health interventions.</td>
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<td></td>
<td></td>
<td>• There are some, however, that think this ratio should be higher.</td>
<td></td>
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</table>

INCREMENTAL COST-EFFECTIVENESS RATIO (ICER)

$$\text{ICER} = \frac{(C_1 - C_0)}{(E_1 - E_0)}$$

$C_1 = \text{Cost of new intervention}$

$C_0 = \text{Cost of the reference intervention}$

$E_1 = \text{Outcome of new intervention (Benefit, Effect or Utility)}$

$E_0 = \text{Outcome of the reference intervention (Benefit, Effect or Utility)}$
INCREMENTAL COST-EFFECTIVENESS RATIO (ICER)

$$ICER = \frac{(C_1 - C_0)}{(E_1 - E_0)}$$

<table>
<thead>
<tr>
<th></th>
<th>Reference treatment</th>
<th>New treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>1000$</td>
<td>1200$</td>
</tr>
<tr>
<td>Outcome (Effect)</td>
<td>65 %</td>
<td>75 %</td>
</tr>
</tbody>
</table>

$$ICER = \frac{1200 - 1000}{75-65} = 20$$ per each 1% increment in effect
### INCREMENTAL COST-EFFECTIVENESS RATIO (ICER)

<table>
<thead>
<tr>
<th></th>
<th>Reference treatment</th>
<th>New treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>1000$</td>
<td>2000$</td>
</tr>
<tr>
<td>Outcome (Effect)</td>
<td>60 %</td>
<td>65 %</td>
</tr>
</tbody>
</table>

**ICER** = \( \frac{(C_1 - C_0)}{(E_1 - E_0)} \)

**ICER** = \( \frac{1200 - 1000}{75 - 65} \)

**ICER** = **200$$** per each 1% increment in effect
More cost

Less cost

Worse outcome

Better outcome

Reference treatment

New treatment
More cost
Less cost
Better outcome
Worse outcome

Reference treatment
New treatment
More cost
Less cost
Better outcome
Worse outcome

Reference treatment dominates
New treatment better outcome but more costly
New treatment less costly but worse outcome
New treatment dominates
More cost

Less cost

Better outcome

Worse outcome

New threshold for ICER

Reference treatment

New treatment
THRESHOLDS FOR ICER

• Level of costs and effects that an intervention must achieve to be acceptable in a given health-care system.
• Hard vs. Soft thresholds
• Threshold approach vs. Budget approach
• Cost-effectiveness affordability

No consensus in US for C/E criterion threshold
Interventions costing less than $100,000 per QALY gained are typically considered economically reasonable
A $50,000 per QALY gained criterion is commonly cited as the minimum of willingness to pay

COST-EFFECTIVENESS OF INTERVENTIONS IN CERVIX CANCER


<table>
<thead>
<tr>
<th>Author</th>
<th>Reported years</th>
<th>By stage</th>
<th>All stages combined</th>
<th>Case-mix</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stage I</td>
<td>Stage II</td>
<td>Stage III</td>
<td>Stage IV</td>
</tr>
<tr>
<td>Komaki et al., 1995</td>
<td>1973</td>
<td>79 %</td>
<td>62 %</td>
<td>25 %</td>
<td>-</td>
</tr>
<tr>
<td>Hanks et al., 1983</td>
<td>1978</td>
<td>75 %</td>
<td>58 %</td>
<td>39 %</td>
<td>-</td>
</tr>
<tr>
<td>Coia et al., 1990</td>
<td>1983</td>
<td>81 %</td>
<td>57 %</td>
<td>47 %</td>
<td>-</td>
</tr>
<tr>
<td>Jones et al., 1995</td>
<td>1984</td>
<td>IA: 93%</td>
<td>IIA: 67%</td>
<td>III: 37%</td>
<td>11 %</td>
</tr>
<tr>
<td>Potter et al., 2000</td>
<td>1993-1997</td>
<td>IA: 100%</td>
<td>IIA: 75%</td>
<td>IIIA: 48%</td>
<td>IVA: 40%</td>
</tr>
<tr>
<td>Chemoradiotherapy, 2008</td>
<td>1987 - 2006</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Han et al., 2013</td>
<td>1998 - 2009</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sturdza et al., 2016</td>
<td>1998-2012</td>
<td>IA: 100%</td>
<td>IIA: 80%</td>
<td>IIIA: 42%</td>
<td>32 %</td>
</tr>
</tbody>
</table>
Considering $1-(M:I)$ as a surrogate for 5yOS.

- 2012: $1-(M:I) = 50\%$
- 2015: $1-(M:I) = 49\%$
- 2020: $1-(M:I) = 48\%$
- 2025: $1-(M:I) = 47\%$
- 2030: $1-(M:I) = 46\%$

**Legend:**
- Blue: Incidence (GLOBOCAN predictions)
- Green: Mortality (GLOBOCAN predictions)
Assuming an immediate implementation of full radiotherapy capacity, the impact over the next years could be a reduction of 22% in the mortality rate.
Cost-effectiveness analysis of 3D image-guided brachytherapy compared with 2D brachytherapy in the treatment of locally advanced cervical cancer

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1Department of Radiation Oncology, University of Pittsburgh Cancer Institute, Pittsburgh, PA
2Department of Medicine, University of Pittsburgh School of Medicine, Pittsburgh, PA

Table 3
ICER for 3D IGBT compared with 2D conventional brachytherapy

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Cost ($)</th>
<th>Incremental cost</th>
<th>Effectiveness (QALY)</th>
<th>Incremental effectiveness (QALY)</th>
<th>ICER ($ per QALY gained)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D</td>
<td>18,817</td>
<td>—</td>
<td>2.01</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3D IGBT (CT)</td>
<td>21,820</td>
<td>3003</td>
<td>2.17</td>
<td>0.16</td>
<td>18,634</td>
</tr>
<tr>
<td>3D IGBT (MRI)</td>
<td>23,293</td>
<td>4476</td>
<td>2.17</td>
<td>0.16</td>
<td>27,774</td>
</tr>
</tbody>
</table>

ICER = incremental cost-effectiveness ratio; 3D = three-dimensional; IGBT = image-guided brachytherapy; 2D = two-dimensional; QALY = quality-adjusted life-year.

- Using the threshold for ICER of $50000, MRI-based brachytherapy can be adopted as treatment of locally advanced cervix cancer.
- Other factors have to be analysed (time consumption…).
**INCREMENTAL COST-EFFECTIVENESS RATIO (ICER)**

**BRACHYTHERAPY IN LOWER-MIDDLE INCOME COUNTRIES**

<table>
<thead>
<tr>
<th></th>
<th>EBRT only</th>
<th>EBRT + 3DBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>1606$</td>
<td>2316$</td>
</tr>
<tr>
<td>Outcome (Effect)</td>
<td>42 %</td>
<td>69 %</td>
</tr>
</tbody>
</table>

\[
\text{ICER} = \frac{(C_1 - C_0)}{(E_1 - E_0)}
\]

\[
\text{ICER} = \frac{2316 - 1606}{69-42}
\]

**ICER = 26$ per each 1% increment in effect**
CONCLUSIONS