Radiotherapy Utilisation Rates

M Barton, G Delaney, J Shafiq, S Jacob, S Thompson, K Wong, T Hanna

Funded by Department of Health and Ageing, Government of Australia
Indications for radiotherapy

• Superior clinical outcome
  – survival
  – local control
  – toxicity profile

• **and** the patient is suitable
  – performance status
  – co-morbidities.
Tree design

- Type/site
- Stage
- Performance status
- Relapse
Example cancer

Localised disease (0.80)

Good PS (0.70)
- RT
- 0.56

Poor PS (0.30)
- No RT

Metastatic disease (0.20)

Good PS (0.60)
- symptoms for RT (0.50)

Poor PS (0.40)
- NO RT
- RT
- 0.06
• 1000+ Pieces of evidence examined
• Constructed RTU trees on 23/23 cancers
• Comprises 98% of all cancer by incidence
• 52% of all cancers need RT
ESTRO project

Towards evidence-based guidelines for radiotherapy infrastructure and staffing needs in Europe: the ESTRO QUARTS project

Søren M. Bentzen, Germaine Heeren, Brian Cottier, Ben Slotman, Bengt Glimelius, Yolande Lievens, Walter van den Bogaert

Gray Cancer Institute and the Cancer Centre, Mount Vernon Hospital, Northwood, UK, ESTRO Office, Brussels, Belgium, Department of Health, National Health Services Analysis Unit, Clatterbridge Centre for Oncology, UK, Radiotherapy Department, Vrije Universiteit Medical Centre, Amsterdam, The Netherlands, Department of Oncology, Radiology and Clinical Immunology, University Hospital, Uppsala, Sweden, Department of Oncology and Pathology, Karolinska Institutet, Stockholm, Sweden, Department of Radiotherapy, University Hospital Gasthuisberg, Leuven, Belgium

% of cases requiring RT
0 - 0.39
0.39 - 0.43
0.43 - 0.47
0.47 - 0.51
0.51 - 0.55
0.55 - 0.59
0.59 - 1

N. Taylor, IAEA 2005
### Other studies

#### Published
- Chemotherapy
- Brachytherapy
- Genetic services
- Screen-detected breast cancer
- Survival benefit breast
- Adaption to LMI countries
- Palliative RT
- Fractionation

#### On going
- Travel distance
- Survival and local control
  - RT
  - Chemotherapy
- Integration with economics


RTU revision 2012

• External beam radiotherapy
• Synchronous chemotherapy
• Brachytherapy
• Patient preference
## RTU revision 2012

<table>
<thead>
<tr>
<th>Site</th>
<th>Old RTU</th>
<th>New RTU</th>
<th>Changed indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>58%</td>
<td>47%</td>
<td>0</td>
</tr>
<tr>
<td>Brain</td>
<td>92%</td>
<td>80%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Breast</td>
<td>83%</td>
<td>87%</td>
<td>0</td>
</tr>
<tr>
<td>Cervix</td>
<td>58%</td>
<td>71%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Colon</td>
<td>14%</td>
<td>4%</td>
<td>-1</td>
</tr>
<tr>
<td>Gall bladder</td>
<td>13%</td>
<td>17%</td>
<td>0</td>
</tr>
<tr>
<td>Head and Neck</td>
<td>74%</td>
<td>74%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Kidney</td>
<td>28%</td>
<td>15%</td>
<td>-1</td>
</tr>
<tr>
<td>Leukaemia</td>
<td>4%</td>
<td>4%</td>
<td>0</td>
</tr>
<tr>
<td>Liver</td>
<td>0%</td>
<td>0%</td>
<td>N/A</td>
</tr>
<tr>
<td>Lung</td>
<td>76%</td>
<td>77%</td>
<td>0</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>65%</td>
<td>73%</td>
<td>4</td>
</tr>
<tr>
<td>Melanoma</td>
<td>23%</td>
<td>21%</td>
<td>3</td>
</tr>
<tr>
<td>Myeloma</td>
<td>38%</td>
<td>45%</td>
<td>3</td>
</tr>
<tr>
<td>Site</td>
<td>Old RTU</td>
<td>New RTU</td>
<td>Changed indications</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>80%</td>
<td>71%</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>50%</td>
<td>19%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Ovary</td>
<td>4%</td>
<td>4%</td>
<td>0</td>
</tr>
<tr>
<td>Pancreas</td>
<td>57%</td>
<td>49%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Prostate</td>
<td>60%</td>
<td>58%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Rectum</td>
<td>65%</td>
<td>60%</td>
<td>0</td>
</tr>
<tr>
<td>Stomach</td>
<td>68%</td>
<td>27%</td>
<td>1</td>
</tr>
<tr>
<td>Testis</td>
<td>49%</td>
<td>7%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Thyroid</td>
<td>10%</td>
<td>4%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Unknown Primary</td>
<td>61%</td>
<td>61%</td>
<td>0</td>
</tr>
<tr>
<td>Uterus</td>
<td>46%</td>
<td>38%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Vagina</td>
<td>100%</td>
<td>94%</td>
<td>Tree changed</td>
</tr>
<tr>
<td>Vulva</td>
<td>34%</td>
<td>39%</td>
<td>Tree changed</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>52.3%</strong></td>
<td><strong>48.3%</strong></td>
<td></td>
</tr>
</tbody>
</table>
Indications

**Added**
- Lymphoma
- Melanoma
- Myeloma
- Oesophagus
- Stomach

**Removed**
- Colon
- Kidney
Radiotherapy utilisation rates

[Bar chart showing the utilisation rates of radiotherapy for different body parts, with blue bars for Old RTU and red bars for New RTU.]
Absolute Percent Change to RTU for all Cancers by Site
2012 versus 2003 Model

- Only change in AIHW data
- AIHW changes plus other changes

-5% -4% -3% -2% -1% 0% 1% 2% 3% 4% 5%

TOTAL (all cancer)
Unknown Primary
Colon
Stomach
Bladder
Rectum
Brain
Lung
Head and Neck
Kidney
Melanoma
Testis
Breast
Uterus
Pancreas
Other
Gall bladder
Thyroid
Leukaemia
Ovary
Vagina
Liver
Vulva
Oesophagus
Cervix
Myeloma
Lymphoma
Prostate
# Synchronous Chemoradiotherapy

<table>
<thead>
<tr>
<th>Tumour Site</th>
<th>Proportion of Notifiable Cancers</th>
<th>Optimal CT-RT Utilization Rate</th>
<th>Proportion of cancers with CT-RT indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>2.0%</td>
<td>9%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Brain</td>
<td>1.4%</td>
<td>53%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Cervix</td>
<td>1.0%</td>
<td>51%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Gall bladder</td>
<td>0.6%</td>
<td>17%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Head and Neck</td>
<td>3.3%</td>
<td>26%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Lung</td>
<td>9.0%</td>
<td>26%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>1.2%</td>
<td>33%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Pancreas</td>
<td>2.1%</td>
<td>35%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Rectum</td>
<td>4.2%</td>
<td>55%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Stomach</td>
<td>1.8%</td>
<td>20%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Vagina</td>
<td>0.1%</td>
<td>78%</td>
<td>0.08%</td>
</tr>
<tr>
<td>Other</td>
<td>5.0%</td>
<td>5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Total</td>
<td>31.7%</td>
<td>28%</td>
<td>8.9%</td>
</tr>
</tbody>
</table>
## Optimal Brachytherapy Utilization

<table>
<thead>
<tr>
<th>Tumour Site</th>
<th>Proportion of Notifiable Cancers %</th>
<th>Optimal BT Utilization Rate %</th>
<th>Optimal BT Utilization Rate for all Cancers %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervix</td>
<td>1</td>
<td>53</td>
<td>0.5</td>
</tr>
<tr>
<td>Melanoma</td>
<td>10</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>Prostate</td>
<td>18</td>
<td>10</td>
<td>1.8</td>
</tr>
<tr>
<td>Uterine Corpus</td>
<td>2</td>
<td>39</td>
<td>0.7</td>
</tr>
<tr>
<td>Vagina</td>
<td>0.1</td>
<td>85</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td><strong>11%</strong></td>
<td><strong>3.3%</strong></td>
</tr>
</tbody>
</table>

Stephen Thompson
Sensitivity analysis

- **Univaritate**
  - 150 variables

- **Multivariate**
  - Monte Carlo simulation

<table>
<thead>
<tr>
<th>Utilisation rate</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
<td>48.3%</td>
</tr>
<tr>
<td>CT RT</td>
<td>8.9%</td>
</tr>
<tr>
<td>Brachytherapy</td>
<td>3.3%</td>
</tr>
</tbody>
</table>
Factors that affect Patient choice

• Treatment
  – Benefits, toxicity, previous experience
• Socio-demographic
  – Age, sex, marriage, dependents
• Clinical
  – Type, stage, LN, recurrence
• Methodology
  – Framing, order of questions, starting point
• Time
• Cognitive/affective
  – Belief in tmt benefits, need to act, regret
• Provider
Actual utilisation

![Graph showing the relationship between the proportion of new cancer cases receiving radiotherapy and the number of linear accelerators per 1000 new cases of cancer. The graph includes data points marked with letters such as FW, M, MW, S, CC, H, W, WS, SWS, NS, and CS. The P value is 0.0023.](image)
Actual utilisation

- NSW 2004 - 2006
- Optimal RTU at diagnosis = 44%

<table>
<thead>
<tr>
<th>Method</th>
<th>RT</th>
<th>%</th>
<th>New cancers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw data</td>
<td>34,442</td>
<td>32%</td>
<td>108,064</td>
<td></td>
</tr>
<tr>
<td>Data linkage 2004-2006</td>
<td>25,917</td>
<td>24%</td>
<td>108,064</td>
<td></td>
</tr>
<tr>
<td>Data Linkage + GIS</td>
<td>24,952</td>
<td>26%</td>
<td>96,803</td>
<td></td>
</tr>
</tbody>
</table>
Effect of travel distance on RTU in NSW & ACT (2004-06)

P < 0.001
Appropriateness

Screen-detected breast cancer

Radiotherapy
Chemotherapy
Hormone therapy

- Recommended & received
- Not recommended & not received
- Not recommended but received
- Recommended but not received

CANCER May 1, 2008, 112 (9): 1912 - 1922
Conclusions

Optimal utilisation
• 48.3% RT
• 8.9% CTRT
• 3.3% BT

Actual utilisation
• Discrepancies between methods
• Appropriateness
Estimating cost and benefit
Melanoma
### Estimating cost and benefit

#### Melanoma

<table>
<thead>
<tr>
<th>Indication</th>
<th>Number of Fractions</th>
<th>Local control</th>
<th>Local control/fractions</th>
<th>Proportion of all cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucosal Melanoma</td>
<td>30</td>
<td>25%</td>
<td>0.83%</td>
<td>1%</td>
</tr>
<tr>
<td>Lentigo</td>
<td>10</td>
<td>98%</td>
<td>9.8%</td>
<td>1%</td>
</tr>
<tr>
<td>Desmoplastic</td>
<td>20</td>
<td>91%</td>
<td>4.55</td>
<td>2%</td>
</tr>
<tr>
<td>LN +ve</td>
<td>20</td>
<td>14%</td>
<td>0.7%</td>
<td>7%</td>
</tr>
<tr>
<td>H&amp;N pT4</td>
<td>20</td>
<td>18%</td>
<td>0.9%</td>
<td>1%</td>
</tr>
<tr>
<td>All cases</td>
<td>3.9</td>
<td>3.5%</td>
<td>0.90%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Adapting model to other jurisdictions

- Cancer data
- Stage data
- Available models
  - RTU
  - Survival
- Cost data
Globocan data sources

- High quality national or regional (coverage >50%): 7%
- High quality regional (coverage 10% to 50%): 11%
- High quality regional (coverage <10%): 42%
- Regional data: 16%
- National data: 5%
- Frequency data: 8%
- No data: 11%
Data quality and GNI/person

A. High quality national or regional (coverage >50%) 7%
B. High quality regional (coverage 10% to 50%) 11%
C. High quality regional (coverage <10%) 42%
D. National data 5%
E. Regional data 16%
F. Frequency data 8%
G. No data 11%

Average GNI/person

- A: $30,000
- B: $35,000
- C: $10,000
- D: $20,000
- E: $5,000
- F: $25,000
- G: $20,000
Top 10 cancers
Individual country variation

Proportion of all cancers

Cervix
<table>
<thead>
<tr>
<th>Tissue</th>
<th>RTU</th>
<th>Stage data</th>
<th>Survival model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung</td>
<td>77%</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Breast</td>
<td>87%</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Stomach</td>
<td>27%</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Liver</td>
<td>0%</td>
<td>n/a</td>
<td>y</td>
</tr>
<tr>
<td>Colorectum</td>
<td>22%</td>
<td>?</td>
<td>y</td>
</tr>
<tr>
<td>Haematology</td>
<td>40%</td>
<td>Y</td>
<td>y</td>
</tr>
<tr>
<td>Cervix uteri</td>
<td>71%</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>71%</td>
<td></td>
<td>y</td>
</tr>
<tr>
<td>Head and Neck</td>
<td>74%</td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Prostate</td>
<td>58%</td>
<td>y</td>
<td>n</td>
</tr>
</tbody>
</table>