Lung Cancer Care Access and Utilization in Southern Maine: Retrospective and Optimization Analyses

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Objectives
- To retrospectively assess utilization of cancer care services and geographic access to lung cancer care
- To present a use-case for optimization methods in improving geographic access to cancer care in a rural state

Background
- Incidence of and mortality due to lung cancer is higher in Maine compared to the rest of US [1]
  - Incidence: 72.1 cases/100,000
  - Mortality: 47.7 deaths/100,000
- Maine is a rural state: access to care is a major challenge for many patients
  - People living in most rural areas must travel 4-6 times further to receive cancer care [2]
  - Distances of >100 miles for treatment are not uncommon [2]

Research Partners
- MMC Center for Outcomes Research and Evaluation
- New England Cancer Specialists
- Healthcare Systems Engineering Inst. (Northeastern University, Boston, MA)
  - Expertise in design and analysis of complex systems of care

Methods
Dataset
- De-identified electronic medical record data from a single oncology center in southern Maine
- Lung cancer diagnoses: Sep 2011 - Dec 2016
  - Demographic & clinical characteristics
    - Age, sex, race, diagnosis, stage at diagnosis, histology
    - Healthcare utilization
      - Number of oncology clinic visits, number and type of images received, treatments prescribed
    - Access to care
      - Dates of service, zip codes

Original Dataset Final Dataset
Patients 1,372 645
Office Visits 16,486 10,926
Imaging 12,879 7,804
Treatment Regimens 1,886 1,410

Excluding patients with missing staging date (n=541), staging date before 2012 (n=45), residential zip code outside of Maine (n=102)

Excluding healthcare visits occurring >1 yr prior to staging

Retrospective Analysis
- Calculate mean, minimum, and maximum for demographics and utilization of services
- Poison regression to analyze relationship between utilization and age, state, and type of cancer
- MATLAB (Mathworks, Natick MA) used for descriptive statistics and regression
- ArcGIS (Esri, Redlands CA) used to calculate distance traveled by road: center of residential zip code to clinic address

Optimization Analysis: Use-Case
- Illustrate how optimization methods and scenario analyses can be used to determine and evaluate potential improvements in geographic access to care

Scenarios of Care Access
1. Single oncology clinic (current dataset)
2. Three existing oncology clinics
   - Optimized location of fourth hypothetical clinic
   - Minimize distance travelled for all patients
   - Minimize distance travelled with 30-mile cutoff
   - Minimize distance travelled with 60-mile cutoff

Use ArcGIS to generate maps and calculate:
- Mean, standard deviation, min, and max travel distances
- Optimize location to minimize overall distance traveled
  - Location-allocation analysis method
  - Minimize impedance (p-median)
  - Chooses location of clinic such that sum of weighed costs between demand points and solution facility is minimized

Results
Demographic and Clinical Characteristics
- Clinical Characteristics

<table>
<thead>
<tr>
<th>Stage</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (11.6%)</td>
<td>II (8.1%)</td>
</tr>
<tr>
<td>III (21.1%)</td>
<td>IV (46.4%)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Histology</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squamous cell (25.2%)</td>
<td>Non-Squamous (74.2%)</td>
</tr>
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Utilization of Lung Cancer Healthcare Services
- 111-143 patients diagnosed with lung cancer each year (average 132 patients)
- Each year clinic serves on average 259 unique lung cancer patients

Average Utilization

<table>
<thead>
<tr>
<th>Office Visits</th>
<th>Treatment Regimens</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,821</td>
<td>235</td>
<td>1,300</td>
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</tbody>
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Average travel distance 42 miles roundtrip (min: 4 miles, max: 656 miles)
- 3.3% of patients travel >200 miles roundtrip for care
- Utilization of cancer care services decreased with increased distance from the clinic, but this relationship was not significant

Optimization Use-Case
- Average travel distance decreases with additional clinics, but maximum travel distances remain high for some patients
- Various optimization methods are possible for locating hypothetic clinics

Key Findings
- 13.6% of patients traveled >30 miles one-way to access care
- 3.3% patients traveled >100 miles
- Several optimization methods and scenarios are possible:
  - Minimize impedance or maximize coverage with cutoffs (30, 60 miles)
  - No optimization algorithm addresses urban/rural disparities
  - Minimizing distance for most people still prioritizes densely populated areas
- Limitations:
  - Data from only 1 oncology clinic
  - Optimization did not consider all existing oncology practices

Future Work
- Evaluate state-wide access to oncology and surgery care for lung cancer
- Assess all existing cancer facilities
- Propose and analyze potential optimal scenarios of care
- Evaluating the use of CHWs & telemedicine to expand access to lung cancer prevention & screening

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