Evaluating Veteran Access to Eye Care Services Using Facility Location Models

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Veteran Eye Care in Georgia
Add Screening Options
What are we trying to solve?

Primary care visit + Tech performs eye screening
What kind of problem is this?

- Combinatorial matching problem
  - Deciding locations to offer eye care and how to staff those locations
- Constrained resources
- Multi-criteria decision
  - Consider cost, distance traveled, number of patients seen, etc.
Problem Statement

• Goal: Evaluate **which locations** to offer eye care screenings and **what providers types** to staff each eye care location

• Assumptions:
  – Patients go to “assigned” clinic for eye care screening
  – One-year time frame
  – Patients have homogeneous screening need (one screening every other year)

• Limitations:
  – Considering eye care screening only (follow-up care not included)
  – No consideration for patients’ provider preferences
Possible eye care locations
• 25 VA locations in Georgia

Decide:
• At which locations do we offer eye care?
• What kind(s) of provider should staff each location?

“Assign” patients
• Each zip code to clinic location(s)

Consider scenarios
• Start from current state
• 15 established locations
• Start from scratch
Model Overview: Feasibility Constraints

- **Patient Capacity**
  - Number of patients assigned to clinic cannot exceed clinic capacity
    - Capacity subject to type/number of providers at each clinic

- **Demand**
  - Percent of patients assigned per zip code should be between a lower and upper required percent

- **Provider Capacity**
  - Each clinic can hold a maximum number of providers

Mathematical formulations:

\[
\sum_{z \in Z} x_{zc}^t \leq v^t \cdot y_c^t \quad \forall \ c \in C, \ \forall \ t \in T
\]

\[
\sum_{t \in T} \sum_{c \in C} x_{zc}^t \geq m \cdot p_z \quad \forall \ z \in Z
\]

\[
\sum_{t \in T} \sum_{c \in C} x_{zc}^t \leq n_u \cdot p_z \quad \forall \ z \in Z
\]

\[
y_c^t \leq g_c^t \quad \forall \ t \in T, \ \forall \ c \in C
\]

\[
\sum_{t \in T} y_c^t \leq g_c \quad \forall \ c \in C
\]
Model Overview: Three objective functions

I. Maximize patients assigned

\[ \text{Maximize } \sum_{z \in Z} \sum_{c \in C} \sum_{t \in T} x_{zc}^t \]

+ constraints: Budget, distance

II. Minimize overall costs

\[ \text{Minimize } \left[ \sum_{c \in C} \sum_{z \in Z} \sum_{t \in T} \left( a_c^r \cdot x_{zc}^t + (d_{zc} \cdot x_{zc}^t) \cdot r + f_c^r \cdot y^t \right) \right] + h \cdot \sum_{z \in Z} (a_n \cdot p_z - \sum_{t \in T} \sum_{c \in C} x_{zc}^t) \]

+ constraints: Patients, distance

III. Minimize maximum furthest distance traveled

+ constraints: Budget, Patients

Minimize \( m \)
Data Overview

- Patients accessing Georgia VA for (any) care in 2017
  - Approximately 200,000 patients considered
  - Group patients by zip code
- Clinic locations
  - 25 VA clinics in Georgia
    - 15 currently offer some type of eye care
- Driving distance from center of each zip code to each clinic location calculated via Google API
- Budget/costs, provider capacities, and other clinic-specific values obtained from VA
- Model implemented in CPLEX
## Results: Maximize Patients Assigned

(max dist: 150 miles)

<table>
<thead>
<tr>
<th>Budget</th>
<th>From scratch</th>
<th>From current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min % seen</td>
<td>min % seen</td>
</tr>
<tr>
<td>Budget</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>$20 Million</td>
<td>28980</td>
<td>27720</td>
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<tr>
<td>$21 Million</td>
<td>45360</td>
<td>44100</td>
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<tr>
<td>$22 Million</td>
<td>60480</td>
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</table>
# Results: Minimize Cost

## From scratch

<table>
<thead>
<tr>
<th>Max Travel Distance (Miles)</th>
<th>0%</th>
<th>5%</th>
<th>10%</th>
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<tbody>
<tr>
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<td>$19,731,600</td>
<td>$19,879,100</td>
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<tr>
<td>150</td>
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<tr>
<td>200</td>
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<td>$19,000,000</td>
<td>$19,568,300</td>
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</table>

## From current

<table>
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<th>Max Travel Distance (Miles)</th>
<th>0%</th>
<th>5%</th>
<th>10%</th>
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<td>$20,832,300</td>
<td>$20,930,500</td>
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<tr>
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<tr>
<td>200</td>
<td>$20,610,700</td>
<td>$20,697,600</td>
<td>$20,954,000</td>
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</table>

(min 5000 total screen)
Results: Minimize Maximum Distance Traveled

<table>
<thead>
<tr>
<th>Min Total Patients</th>
<th>0%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10000</td>
<td>5</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>20000</td>
<td>8</td>
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</tr>
<tr>
<td>30000</td>
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<td>inf</td>
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<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
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<td>6</td>
<td>87</td>
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</tr>
<tr>
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<tr>
<td>30000</td>
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<td>inf</td>
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(budget: $21M)
Conclusions & next steps

• Maximizing number of patients assigned to screening is objective of most interest to clinical collaborators

• Incorporate stochasticity
  – Consider patients not visiting their “assigned” clinic

• Consider implications for follow-up care
  – How are ophthalmologist/optometrist case mixes impacted?

• Generalize beyond Georgia
  – Apply to other VA regions considering robust eye care options
Acknowledgements

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