Evaluating Veteran Access to Eye Care Services Using Facility Location Models

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INFORMS HAS

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What are we trying to solve?

VA primary care visit + Tech performs eye screening (TECS Program)
Background

- Low-vision/blindness can have debilitating effects
  - Challenge with low-vision and driving
- Prevalence of diabetes in VA patients (11.4%) higher than general US population (7.2%)
  - Diabetes strongly associated with eye disease and vision impairment
Background, continued

• Why VA research?
  – VA is cost-incentivized to reduce barriers to accessing care
  – Patient utilization of care is relatively consistent

• Why this population?
  – Veterans report greater delays in seeking care than non-veterans
  – Eye care is 3rd most utilized service in VA (after primary care and mental health)
Problem Statement

• Goal: Evaluate **which locations** to offer eye care screenings and **what provider type(s)** 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
What kind of problem is this?

- 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.
General Modeling Approach

Possible eye care locations
• 25 VA locations in Georgia

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

Assign patients
• Patients from a given zip code assigned to clinic location(s)

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

• Patient Capacity

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

• Demand

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

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

• Provider Capacity

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

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

I. Maximize patients assigned
   + constraints: budget, distance

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

II. Minimize overall costs
   + constraints: patients, distance

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

III. Minimize furthest distance traveled
   + constraints: budget, patients

\[ \text{Minimize } m \]
Data Overview

- Patients accessing Georgia VA for (any) care in 2017
  - Approx. 200,000 patients, grouped by zip code
- Clinic locations
  - 25 VA clinics in Georgia
- 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 C++ and solved using CPLEX
Results

Model: Maximize Patients Assigned

Constraints:
• Budget: Vary ($20M-$22M)
• Max. Distance Traveled: 150 miles
Results: Maximize Patients Assigned

Constraints: Budget and Max. Distance Traveled

Minimum % of Patients Assigned from Each Zip Code

- $20 Million
- $21 Million
- $22 Million

(max dist: 150 miles)
Results

Model: Minimize Furthest Distance Traveled

Constraints:
- Minimum Patients: Vary (10K – 30K patients)
- Budget: $21M
Results: Minimize Furthest Distance Traveled

Constraints: Minimum Patients and Budget

- (budget: $21M)
- 10,000 patients
- 20,000 patients
- 30,000 patients
Model: Minimize cost
Constraints:
• Max. Distance Traveled: Vary (90-130 miles)
• Minimum Patients: Vary (10K – 40K patients)
Results: Minimize Cost

Constraints: Max. Distance Traveled and Minimum Patients

<table>
<thead>
<tr>
<th>Minimum % Patients from each Zip Code</th>
<th>0%</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 Maximum Distance Traveled (miles)</td>
<td>512,100</td>
<td>520,400</td>
<td>515,800</td>
<td>578,900</td>
<td>633,800</td>
</tr>
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<td>100 Maximum Distance Traveled (miles)</td>
<td>461,000</td>
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<td>586,800</td>
<td>1,070,100</td>
<td>1,633,800</td>
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<tr>
<td>110 Maximum Distance Traveled (miles)</td>
<td>490,400</td>
<td>580,900</td>
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<td>1,624,600</td>
<td>1,641,600</td>
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<tr>
<td>120 Maximum Distance Traveled (miles)</td>
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<tr>
<td>130 Maximum Distance Traveled (miles)</td>
<td>490,400</td>
<td>1,070,100</td>
<td>1,624,600</td>
<td>1,641,600</td>
<td>1,641,600</td>
</tr>
</tbody>
</table>
• Uncertainty in population distribution
• Two-stage stochastic formulation to maximize the total number of people assigned to all clinics

**First Stage**

• **Open Clinic**
  \[ \sum_{c \in C} \delta_{zc} \cdot y_c \geq 1 \quad \forall \ z \in Z \]

• **Staff Clinic**
  \[ y_c^t \leq g_c^t \cdot y_c \quad \forall t \in T, \forall c \in C \]

• **Provider Capacity**
  \[ \sum_{t \in T} y_c^t \leq g_c \quad \forall c \in C \]
• **Second Stage**
  – Budget Constraint
  – Furthest Traveling Distance Allowed
  – Patient Capacity Requirement
  – Demand Requirement
  – Objective: Maximize the number of patients assigned to all clinics
Practical Challenges

• Physician collaborator would like to use this model and apply it in different (not yet defined) scenarios
  – Current model solved with CPLEX
    • CPLEX requires expensive licensing fee and technical support
• Challenge: find alternative ways for physician to solve model with new scenarios
Conclusions & Next Steps

- Maximizing number of patients assigned is of most interest to clinical collaborators
- Each objective function inherently considers trade-offs
- Tool can be used by VA when evaluating community care integration
- Next…
  - Further explore stochasticity
  - Consider implications for follow-up care
  - Generalize beyond Georgia
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