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# Evaluating Veteran Access to Eye Care Services Using Facility Location Models

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INFORMS HAS

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CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
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M | CHEPS

Rx

A prescription to address system complexity in healthcare

INNOVATING HEALTHCARE DELIVERY

FOSTERING LEARNING

BUILDING COMMUNITY

POSITIVE IMPACT THROUGH...

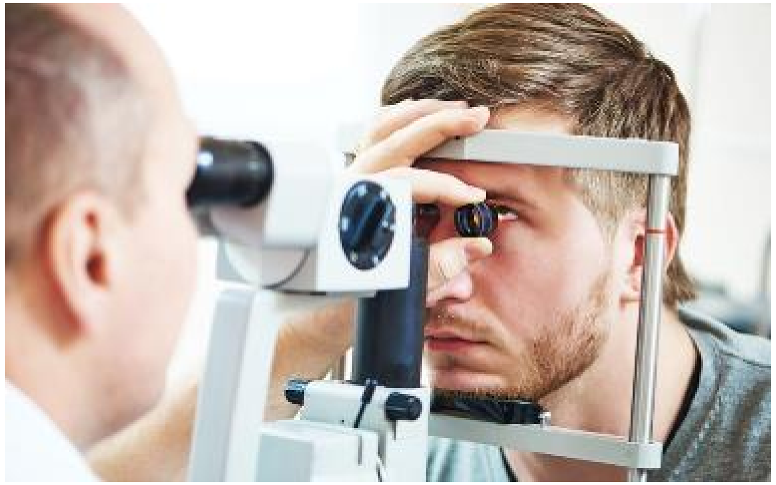
Research
Education
Implementation
Outreach
Dissemination

# 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**

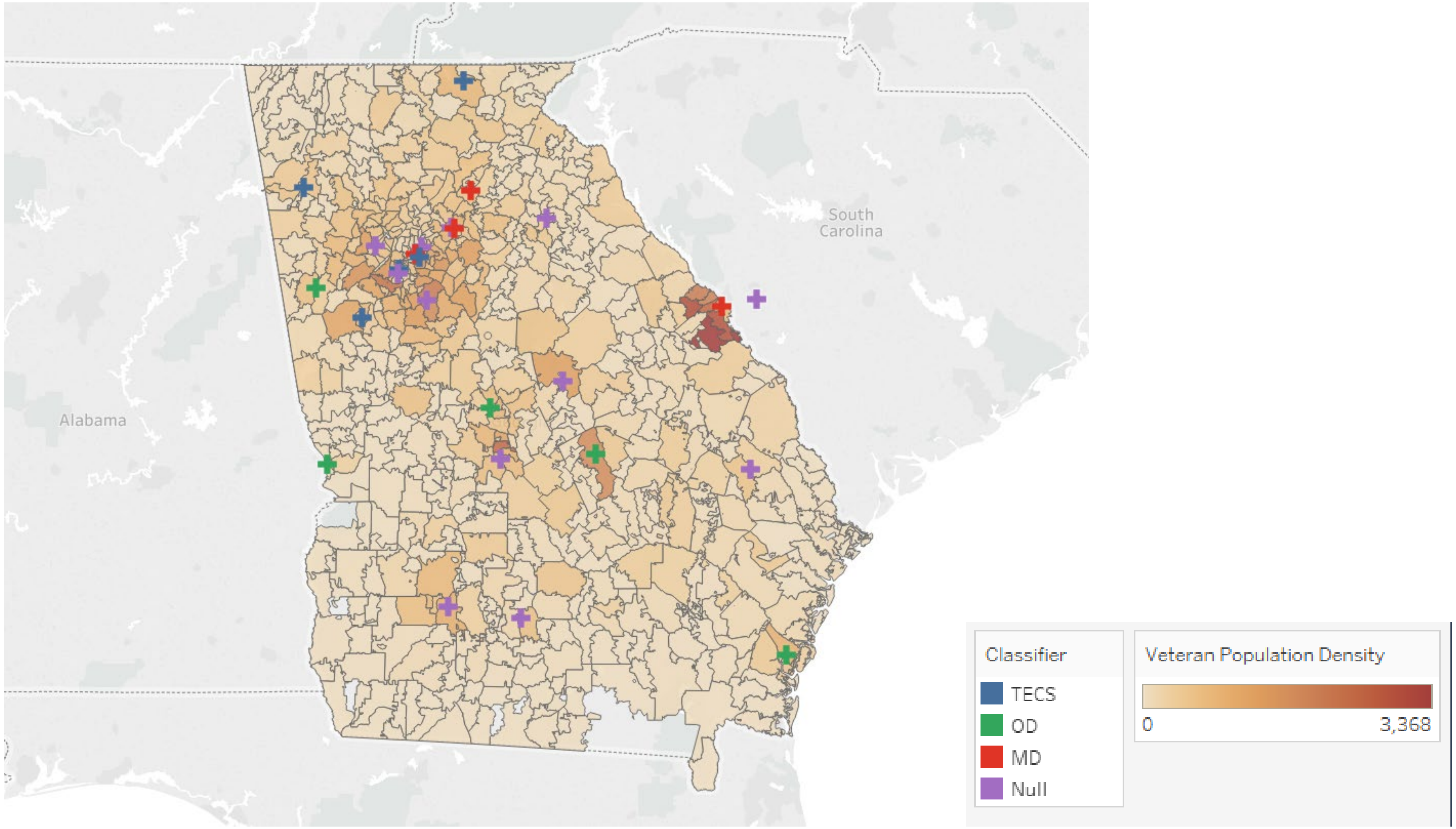
- Patients from a given zip code assigned to clinic location(s)

**Consider scenarios**

- Start from current state
- Start from scratch

# Map of VA Clinics





# Model Overview: Feasibility Constraints

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- Patient Capacity

$$\sum_{z \in Z} x^t_{zc} \leq v^t * y^t_c \qquad \forall\, c \in C,\ \forall t \in T$$

- Demand

$$\sum_{t \in T} \sum_{c \in C} x^t_{zc} \geq n_l * p_z \qquad \forall\, z \in Z$$

$$\sum_{t \in T} \sum_{c \in C} x^t_{zc} \leq n_u * p_z \qquad \forall\, z \in Z$$

- Provider Capacity

$$y^t_c \leq g^t_c \qquad \forall t \in T, \forall c \in C$$

$$\sum_{t \in T} y^t_c \leq g_c \qquad \forall c \in C$$

# Model Overview: Three objective functions

**I. Maximize patients assigned**

+ constraints: budget, distance

$$Maximize \sum_{z\in Z}\sum_{c\in C}\sum_{t\in T} x^t_{zc}$$

**II. Minimize overall costs**

+ constraints: patients, distance

$$Minimize \left[\sum_{c\in C}\sum_{z\in Z}\sum_{t\in T}(a^t_c * x^t_{zc} + (d_{zc} * x^t_{zc}) * r + f^t_c * y^t_c)\right] + h * \sum_{z\in Z}(n_u * p_z - \sum_{t\in T}\sum_{c\in C} x^t_{zc})$$

**III. Minimize furthest distance traveled**

+ constraints: budget, patients

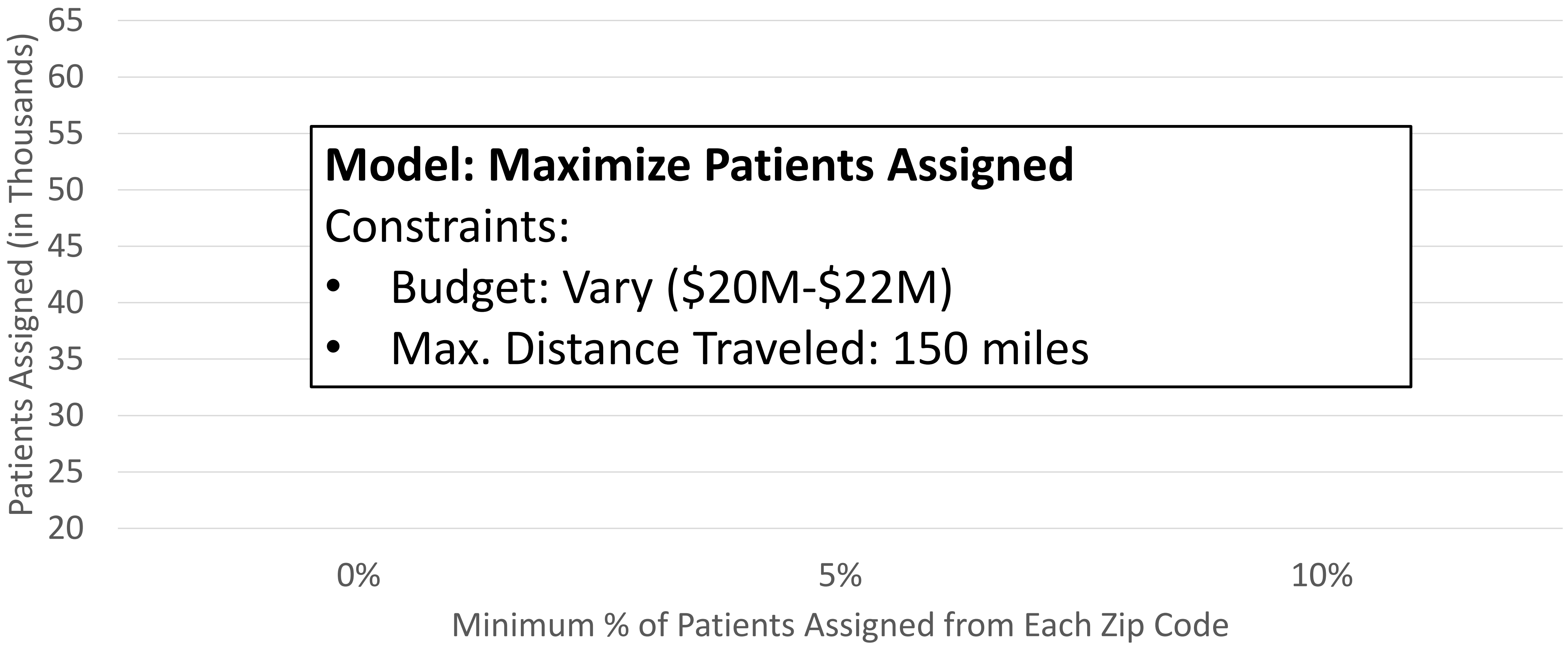
$$Minimize\ m$$

# 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

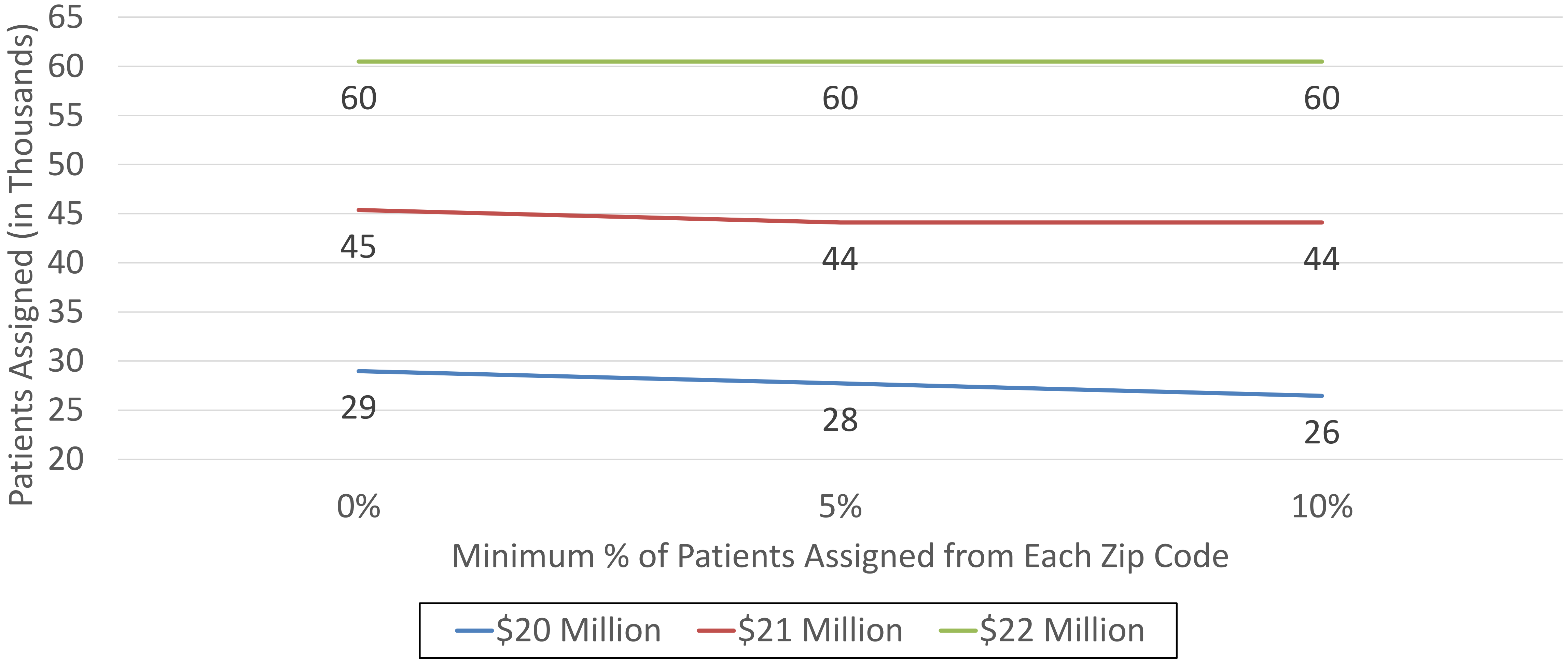
# Results



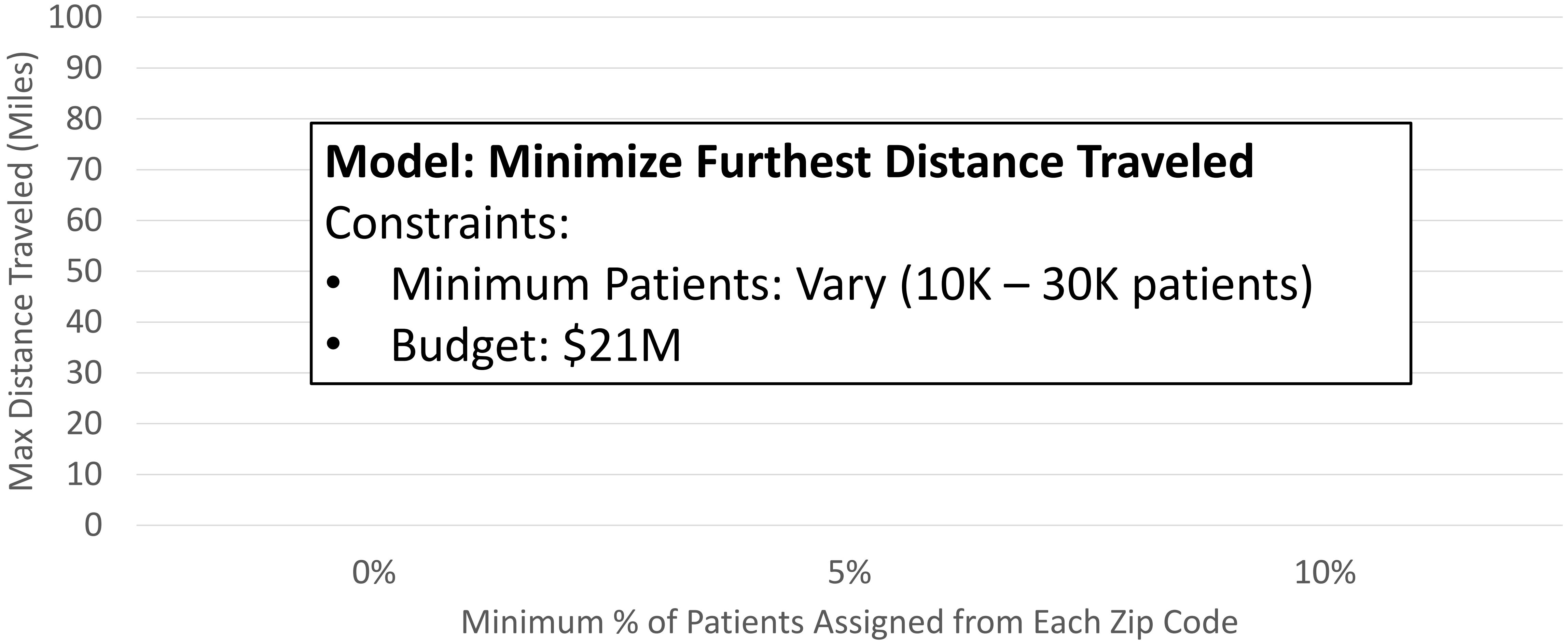

Patients Assigned (in Thousands)
65
60
55
50
45
40
35
30
25
20
Model: Maximize Patients Assigned
Constraints:
• Budget: Vary ($20M-$22M)
• Max. Distance Traveled: 150 miles
0%
5%
10%
Minimum % of Patients Assigned from Each Zip Code

# Results: Maximize Patients Assigned

Constraints: Budget and Max. Distance Traveled




(max dist: 150 miles)



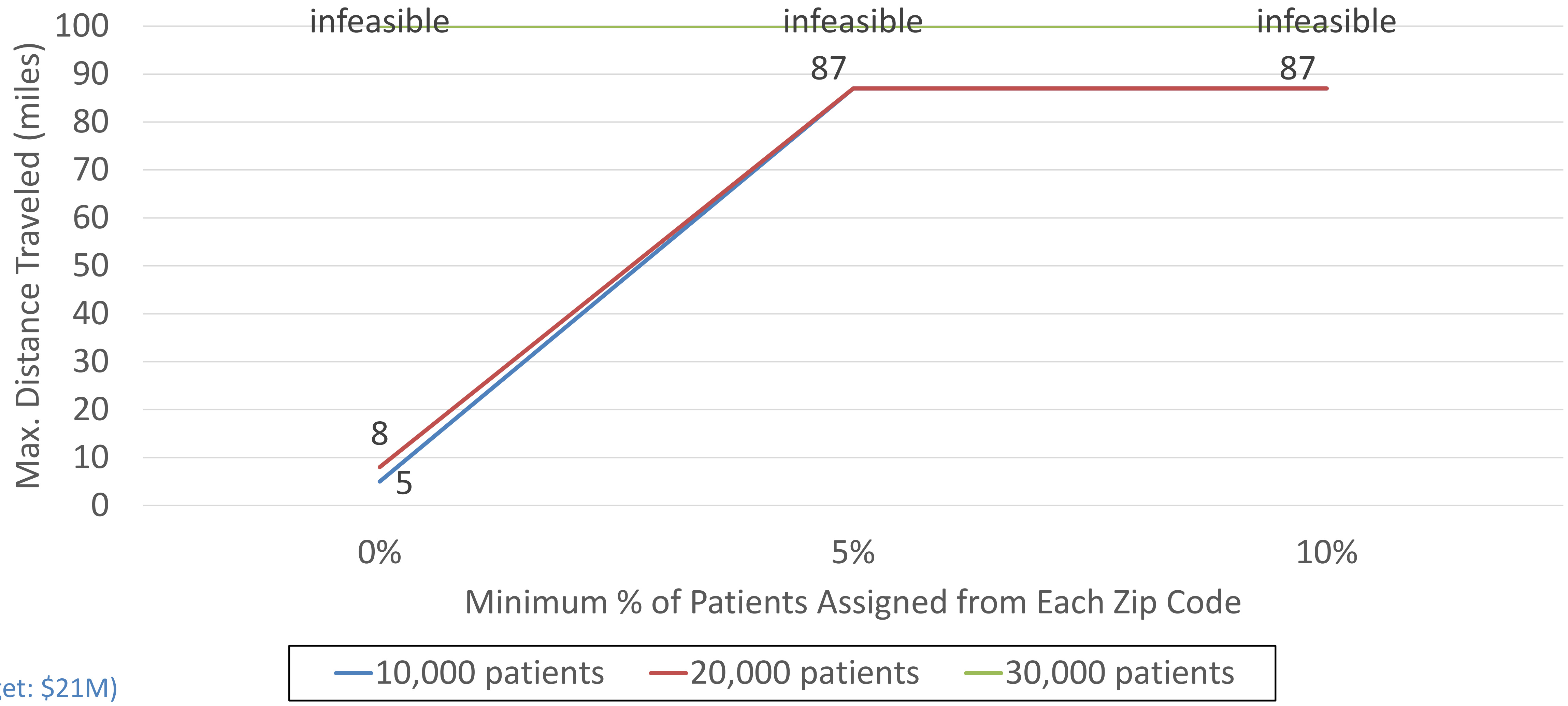

**Model: Minimize Furthest Distance Traveled**

Constraints:

- Minimum Patients: Vary (10K – 30K patients)
- Budget: $21M

# Results: Minimize Furthest Distance Traveled

Constraints: Minimum Patients and Budget




(budget: $21M)

# Results

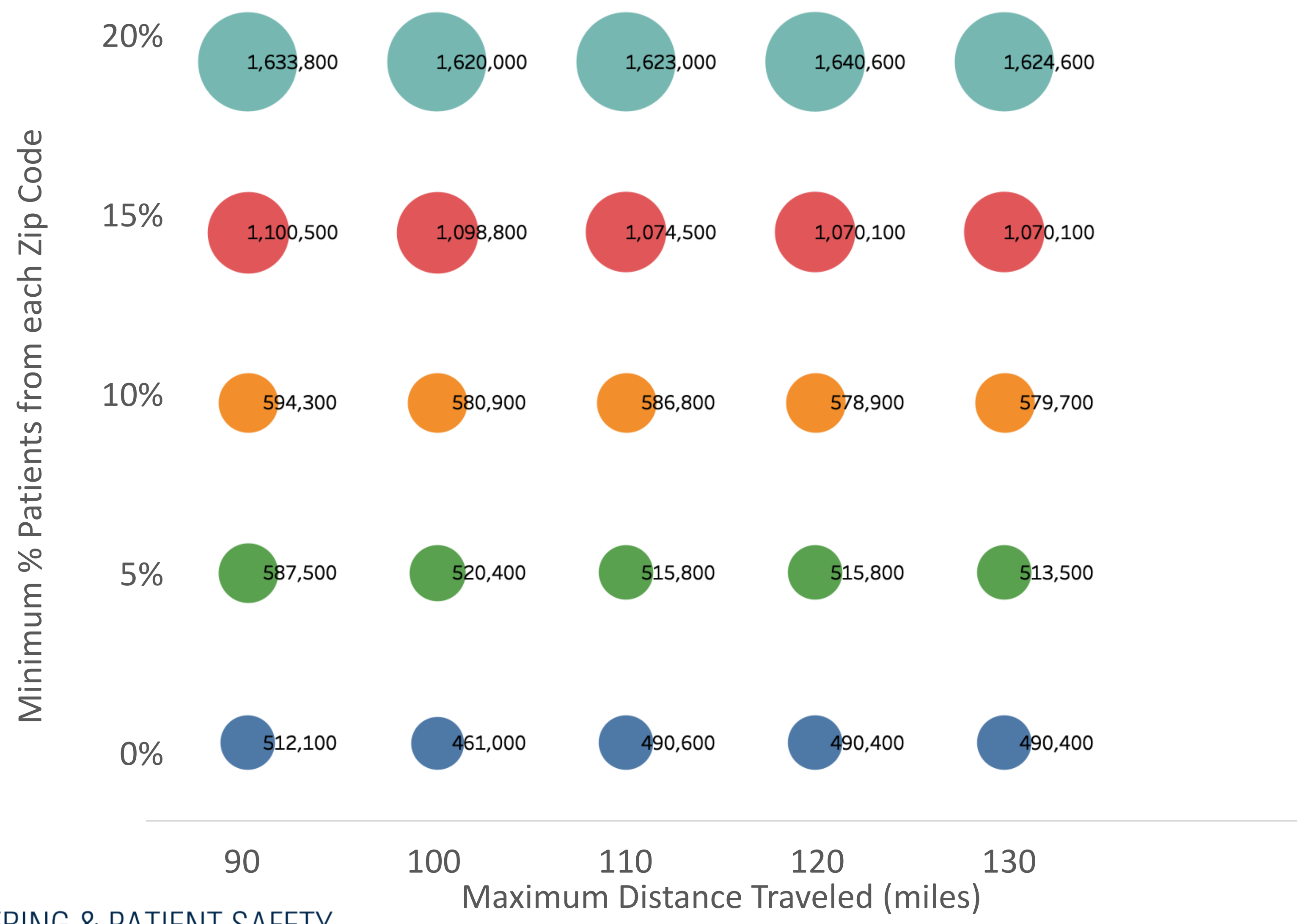
**Model: Minimize cost**

Constraints:

- Max. Distance Traveled: Vary (90-130 miles)
- Minimum Patients: Vary (10K – 40K patients)

# Results: Minimize Cost

Constraints: Max. Distance Traveled and Minimum Patients



# Stochastic Formulation

- Uncertainty in population distribution
- Two-stage stochastic formulation to maximize the total number of people assigned to all clinics

- First Stage
  - Open Clinic

$$Subject\ to \sum_{c \in C} \delta_{zc} * y_c \geq 1 \ \forall \ z \in Z$$

  - Staff Clinic

$$y_c^t \leq g_c^t * y_c \qquad \forall t \in T, \forall c \in C$$

  - Provider Capacity

$$\sum_{t \in T} y_c^t \leq g_c \qquad \forall c \in C$$

# Stochastic Formulation

- 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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