ASTRO'S 67TH ANNUAL MEETING

REDISCOVERING RADIATION MEDICINE AND EXPLORING NEW INDICATIONS

A novel simulation framework for evaluating and optimizing oncology outreach policies

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Dartmouth GEISEL SCHOOL OF MEDICINE

BACKGROUND

- Oncology outreach is a common strategy for addressing rural workforce shortages, where oncologists commute across healthcare settings to extend care to underserved populations
- No analytical methods exist for optimizing outreach arrangements

GENERATION OF COUNTERFACTUALS

We used EHR data to estimate two "generators" that are used to construct counterfactual control and policy groups in each simulation

Example: Shift 25% of new medical oncology visits from Lebanon (hub) to St. Johnsbury ($\theta = 0.25$)

Retain original distribution of new patient visits

"Physician Generator"
Avg annual new patient visits at each oncologist/site

Randomly reallocate hub patient visits to satellite (as specified by θ)

$C_{ctl} =$

Oncologist >>	A	B	C
Site >>	LEB	KNE	LEB
New Visits >>	2	2	6
Patient >> 1	78.6	91.0	78.6
2	65.5	119.8	65.5
3	30.6	94.6	30.6
4	65.5	119.8	65.5
5	78.6	91.0	78.6
6	2.8	62.3	2.8
7	53.5	102.3	53.5
8	78.6	91.0	78.6
9	53.5	102.3	53.5
10	30.6	94.6	30.6

Round-trip travel times

Modified columns

$= C_{pol}$

A	B	C	C
LEB	KNE	LEB	STJ
2	3	4	2
78.6	91.0	78.6	20.7
65.5	119.8	65.5	39.9
30.6	94.6	30.6	35.9
65.5	119.8	65.5	39.9
78.6	91.0	78.6	20.7
2.8	62.3	2.8	56.1
53.5	102.3	53.5	13.1
78.6	91.0	78.6	20.7
53.5	102.3	53.5	13.1
30.6	94.6	30.6	35.9

Sample with replacement

"Patient Generator"
Joint distribution for patient residence, cancer, stage

ASSIGNMENT OF PATIENTS TO PHYSICIANS

For each counterfactual group, we assume patients "choose" their closest available oncologist/site on a first-come-first-served basis

Cost Matrix

$C_{pol} =$

Oncologist >>	A	B	C	C
Site >>	LEB	KNE	LEB	STJ
New Visits >>	2	2	4	2
Patient >> 1	78.6	91.0	78.6	20.7
2	65.5	119.8	65.5	39.9
3	30.6	94.6	30.6	35.9
4	65.5	119.8	65.5	39.9
5	78.6	91.0	78.6	20.7
6	2.8	62.3	2.8	56.1
7	53.5	102.3	53.5	13.1
8	78.6	91.0	78.6	20.7
9	53.5	102.3	53.5	13.1
10	30.6	94.6	30.6	35.9

Assignment Matrix

$A'_{pol} =$

Oncologist >>	A	B	C	C
Site >>	LEB	KNE	LEB	STJ
New Visits >>	2	2	4	2
Patient >> 1	0	0	0	1
2	0	0	0	1
3	1	0	0	0
4	1	0	0	0
5	0	0	1	0
6	0	0	1	0
7	0	0	1	0
8	0	0	1	0
9	0	1	0	0
10	0	1	0	0

We use simulations to optimize outreach policies that reallocate oncologist effort between a hub and satellite facility/clinic

SIMULATION FRAMEWORK

1 Conceive of Policy → **2 Simulate Control & Policy Counterfactuals** → **3 Compare Groups**

Inputs

Satellite candidate
Oncology specialty
% of new patient visits to shift (θ)

Generate the counterfactuals | *Assign patients to physicians* | *Calculate total patient travel times*

C_{ctl} → $f(C)$ → $\langle C, A' \rangle_{ctl}$

$C_{pol} \sim g(\theta)$ → $f(C)$ → $\langle C, A' \rangle_{pol}$

Repeat thousands of times

Output

We are interested in comparing means!

The goal is to optimize patient travel time savings with respect to θ:

$$\theta^* = \arg\max_{\theta} \frac{1}{N} \sum_{i=1}^{n} \langle C_i, A_i \rangle_{ctl} - \langle C_i, A_i \rangle_{pol} \quad \text{where} \quad C_{i,pol} \sim g(\theta)$$

How? Exhaust the sample space for $\boldsymbol{\theta} \in \{5\%, 10\%, \ldots, 100\%\}$ and find the value that maximizes patient travel time savings (via grid search)

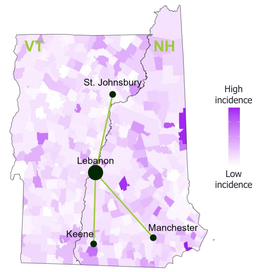
PRINCIPAL FINDINGS

(A) Test Case #1

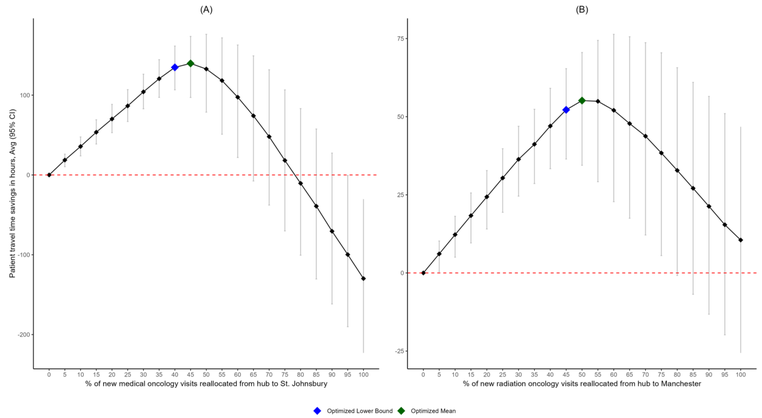
Reallocate **medical oncology** effort from Lebanon to **St. Johnsbury**

(B) Test Case #2

Reallocate **radiation oncology** effort from Lebanon to **Manchester**



Breast, colorectal, and lung cancer incidence by ZCTA within DH catchment



FUTURE DIRECTIONS

- Extend methods to consider optimization across >2 facilities
- Incorporate health system financials and physician preferences into objective function (i.e., multi-objective optimization)
- Scale methods into software and grant service line leads access to support outpatient staffing decisions
- Explore prospective study and conduct cost-benefit analysis

C: Cost matrix, containing round-trip patient travel times for potential physician assignments
A': Assignment matrix, indicating patient-physician assignments

$\langle C, A' \rangle$: Total incurred patient travel time given physician assignments within a group
$\langle C, A' \rangle_{ctl} - \langle C, A' \rangle_{pol}$: Patient travel time savings (or spending) attributable to the policy

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