

Patient Travel and Treatment Center Selection for New Gene Therapies in Brazil

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Project Overview



Project Blurp

Optimizing Gene Therapy Supply Chains and Patient Travel

How can optimization modeling shed light on how patient travel considerations could be incorporated into gene therapy treatment center selection?

After exploring various steps along the gene therapy supply chain and their connections to patient access, we've decided to focus on gene therapy treatment center selection and patient travel. Choosing how many and which treatment centers at which to offer a gene therapy to patients is a crucial decision which impacts how far the treatment has to be transported and how far patients have to travel to receive treatment. Many gene therapies are for patients with severe diseases that make it difficult to travel. On the other hand, cold chain requirements give gene therapies short transport windows and expensive transportation costs. Using optimization modeling paired with local input we hope to explore how to best balance these considerations as the supply chain is being designed. Expected outputs of this work are a case study on a product in Brazil, a model that could be used for other cases, and a thesis.

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Project Timeline



Scope



Background on Brazil

Statistics:

- 3.3 million mi² / 8.5 million km² area
- 26 states, 1 federal district
- 215.3 million people

Health system:

- Sistema Único de Saúde (SUS)
 - Government-run, public health system
 - Free, universal care
- Product in pre-approval distribution stage, working towards approval

Currency:

- Brazilian Real (BRL)
 - 1 BRL \approx 0.2 USD
 - 5 BRL \approx 1 USD

Focus on treatment infusion locations

Referral Center (Diagnosis, eligibility, & follow-up)

- Requires specialized physician
- Does **not** require center willingness to handle high value product
- Does **not** require gene therapy product

Treatment Center (Infusion)

- Requires specialized physician *with extra training*
- Requires center willingness to handle high value product
- Requires gene therapy product

Focus of my project

Focus on TC-selection-dependent costs

1. Country entry cost

- Health authority approval process
- Country health system incorporation process

Not dependent on TC selection

2. Patient cost (cost per patient treated)

- Fixed cost of treatment
- Fixed cost of administration
- Fixed cost of cold chain treatment transportation into country

3. Treatment center fixed cost (cost per treatment center)

- Site contracting and physician registration
- Site training on operations process
- Database maintenance IT cost
- Admin helpline burden

4. Last-mile variable treatment transport cost (proportional to distances from country entry point to treatment centers)

- Additional cold chain transport mileage
- Incremental cold chain duration

Focus of my project

5. Patient travel variable cost (proportional to distances from patients to treatment centers)

- Additional cost to further travel
- Additional burden to further travel beyond 'travel cost', esp. with potential for multiple required trips

Model



Model: Balancing three factors

Treatment center cost

(cost per center)

The higher priority this is, the smaller the number of centers.

The lower priority this is, the larger the number of centers.

Last-mile treatment transport cost

(cost per km of in-country treatment transportation)

The higher priority this is, the closer treatment centers will be to the treatment start points.

The lower priority this is, the farther treatment centers will be to the treatment start points.

Patient travel cost

(cost per km of patient travel)

The higher priority this is, the closer treatment centers will be to patients.

The lower priority this is, the farther treatment centers will be to patients.

Data Inputs

Parameter Costs		High	Medium	Low
	Patient travel (cost * # trips) per km	20	4	2
	Treatment transport per km	10	2	1
	Center fixed cost	500,000	100,000	50,000

Shapefiles (map boundaries and coordinates)	geobr package
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Approach definitions	Ex: Centralize Center cost: HIGH Patient travel: LOW Treatment transport: MEDIUM Options: 15 biggest cities
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Treatment start points	GRU GYN
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Estimated patient populations	Census data & prevalence data
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Center candidates

Biggest City in Each State		
	City	Region
2	São Paulo	São Paulo
3	Brasília	Distrito Federal
4	Salvador	Bahia
5	Belo Horizonte	Minas Gerais
6	Rio de Janeiro	Rio de Janeiro
7	Florianópolis	Santa Catarina
8	Porto Alegre	Rio Grande do Sul
9	Recife	Pernambuco
10	Manaus	Amazonas
11	Fortaleza	Ceará
12	Curitiba	Paraná
13	João Pessoa	Pernambuco
14	Maceió	Alagoas
15	Aracaju	Serpe
16	Serra	Espírito Santo
17	Joinville	Santa Catarina
18	Campo Grande	Mato Grosso do Sul
19	Cuiabá	Mato Grosso

15 Most Populous Cities		
	City	Region
2	São Paulo	São Paulo
3	Brasília	Distrito Federal
4	Salvador	Bahia
5	Belo Horizonte	Minas Gerais
6	Rio de Janeiro	Rio de Janeiro
7	Florianópolis	Santa Catarina
8	Porto Alegre	Rio Grande do Sul
9	Recife	Pernambuco
10	Manaus	Amazonas
11	Fortaleza	Ceará
12	Curitiba	Paraná
13	João Pessoa	Pernambuco
14	Maceió	Alagoas
15	Aracaju	Serpe

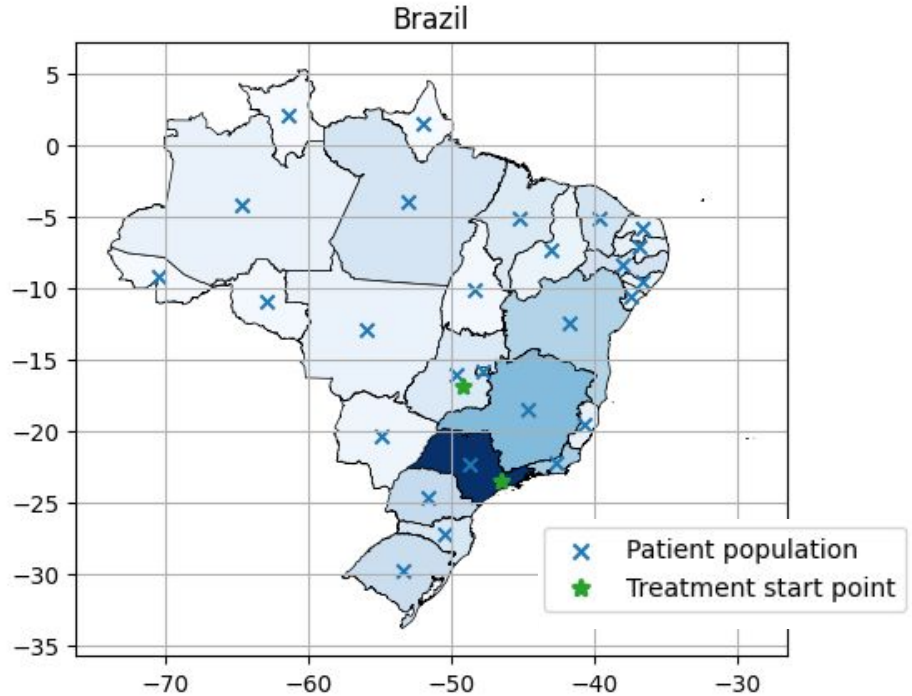
RD Reference Center Cities			
		City	Region
2		Rio de Janeiro	Rio de Janeiro
3		Brasília	Distrito Federal
4		Salvador	Bahia
5		Belo Horizonte	Minas Gerais
6		Rio de Janeiro	Rio de Janeiro
7		Florianópolis	Santa Catarina
8		Porto Alegre	Rio Grande do Sul
9		Recife	Pernambuco
10		Manaus	Amazonas
11		Fortaleza	Ceará
12		Curitiba	Paraná
13		João Pessoa	Pernambuco
14		Maceió	Alagoas
15		Aracaju	Serpe

Previous GT Cities		
	City	Region
2	São Paulo	São Paulo
3	Salvador	Bahia
4	Belo Horizonte	Minas Gerais
5	Rio de Janeiro	Rio de Janeiro
6	Florianópolis	Santa Catarina
7	Porto Alegre	Rio Grande do Sul
8	Recife	Pernambuco
9	Manaus	Amazonas
10	Fortaleza	Ceará
11	Curitiba	Paraná
12	João Pessoa	Pernambuco
13	Maceió	Alagoas
14	Aracaju	Serpe

4 "Main" Cities		
	City	Region
2	São Paulo	São Paulo
3	Rio de Janeiro	Rio de Janeiro
4	Salvador	Bahia
5	Belo Horizonte	Minas Gerais
6	Florianópolis	Santa Catarina
7	Porto Alegre	Rio Grande do Sul
8	Recife	Pernambuco
9	Manaus	Amazonas
10	Fortaleza	Ceará
11	Curitiba	Paraná
12	João Pessoa	Pernambuco
13	Maceió	Alagoas
14	Aracaju	Serpe

Fixed Model Parameters

- Number of patients
- Population distribution
- Treatment start points (where the gene therapy treatment enters the country)



582 patients, distributed proportionally to the population

Treatment enters the country at GRU and GYN airports

Baseline Costs

Treatment center cost (cost per center)

Based on the line-item breakdown of distribution costs from an international distributor for the pre-approval stage in Brazil, we came up with a lower bound of 8,500 EUR for the cost per treatment center location, which is approximately **50,000 BRL**

Last-mile treatment transport cost

(cost per km of in-country treatment transportation)

Based on a driving-distance calculator, using the trip from Cuiabá, MT to Goiânia, GO as a representative trip, we estimated a lower bound of 0.2 USD/km, which is approximately **1 BRL/km**

Patient travel cost (cost per km of patient travel)

Assuming patients will need to travel both to and from treatment center locations, we therefore estimated a lower bound of 0.4 USD/km of distance ($= 2 * 0.2$ USD/km), which is approximately **2 BRL/km**


Since these lower bounds were significant underestimates, they were doubled to come up with our MEDIUM (1x) reference costs used to make model estimations

Menu of Input Options

- Candidate locations
- Priority levels for:
 - Patient travel
 - Treatment transportation
 - Center costs

<u>Candidate locations</u>		
Locations with previous GT experience	Government RD reference center locations	Biggest cities in each state
<u>Patient travel cost priority level</u>		
HIGH (5x)	MEDIUM (1x)	LOW (0.5x)
<u>Treatment transportation cost priority level</u>		
HIGH (5x)	MEDIUM (1x)	LOW (0.5x)
<u>Center fixed cost priority level</u>		
HIGH (5x)	MEDIUM (1x)	LOW (0.5x)

Results

- Five defined approaches
 - Interactive workshop results
- 

Five Approaches to TC-Selection



Approach descriptions

Centralize

Minimize complexity by centralizing and limiting the number of centers. Not concerned much with patient travel.

Candidate locations:
15 Biggest cities

Priorities:
Center: HIGH,
Transport: MEDIUM,
Patient: LOW

Copy Prev. Therapy

Only consider centers which already provide other gene therapies. The treatment center cost priority is low, as the centers are mostly setup.

Candidate locations:
Cities with previous gene therapy offerings

Priorities: Center: LOW,
Transport: MEDIUM,
Patient: MEDIUM

Early Physicians

Allow influential physicians in the biggest states to defacto choose by bringing the treatment to their centers.

Candidate locations:
4 "main" cities

Priorities:
Center: MEDIUM,
Transport: MEDIUM,
Patient: MEDIUM

Government

The government decides to spread treatment centers among existing rare disease reference centers. Not interested in transportation costs as those likely born by the company.

Candidate locations:
Cities with rare disease reference centers

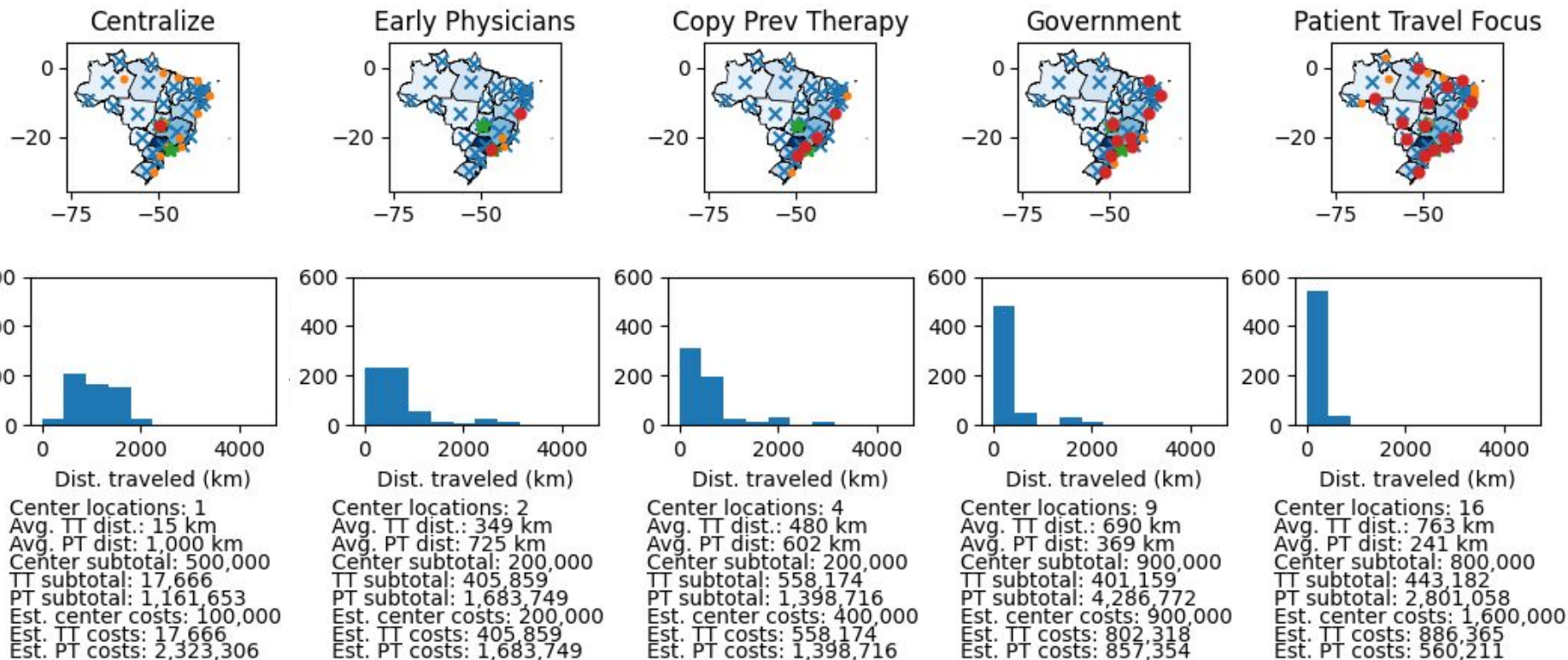
Priorities:
Center: MEDIUM,
Transport: LOW,
Patient: HIGH

Patient Travel Focus

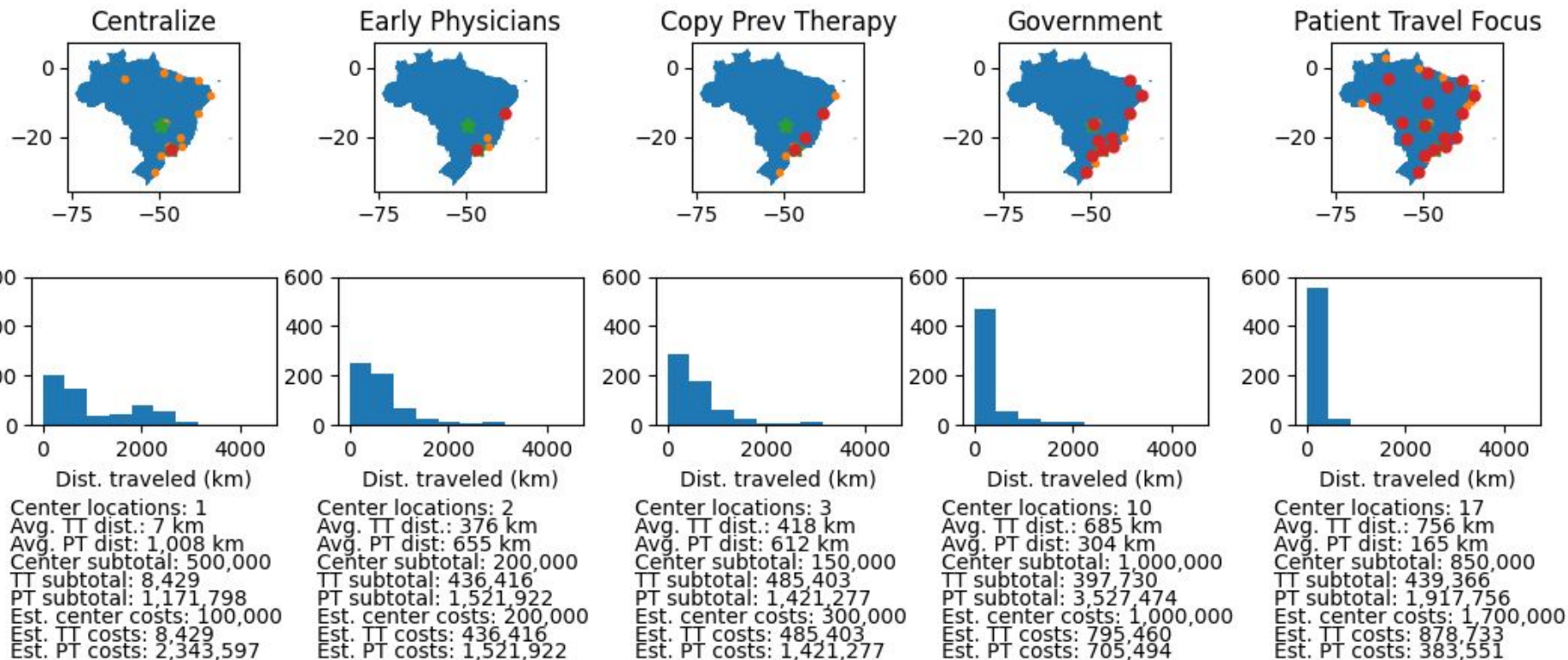
Strong focus on patient travel.

Candidate locations:
Biggest city in each state

Priorities:
Center: LOW,
Transport: LOW,
Patient: HIGH



State-level patient populations

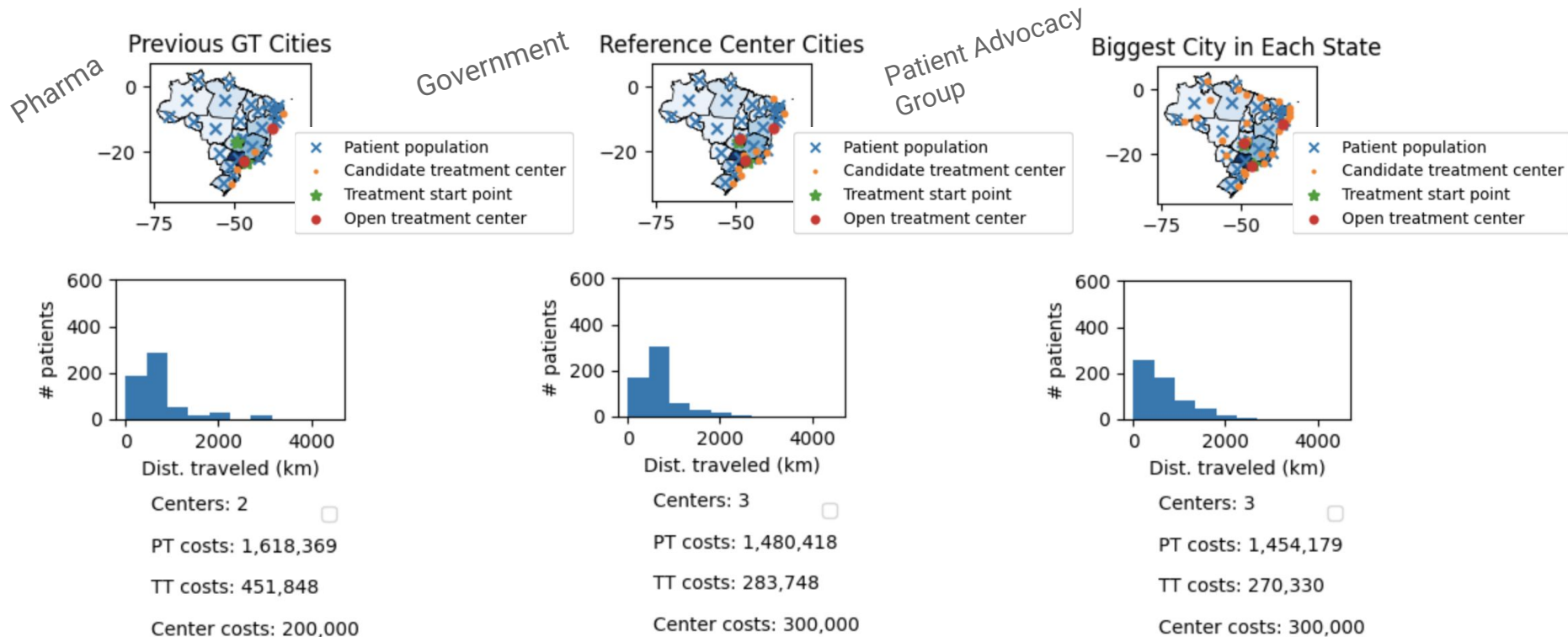


Municipality-level patient populations

Interactive Workshop Results

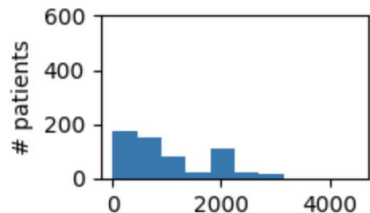
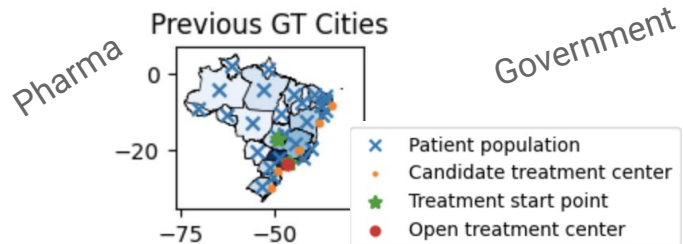


All Medium Priority (*pre-workshop*)



High Top Priority, Others Medium (*pre-workshop*)

HIGH treatment transport



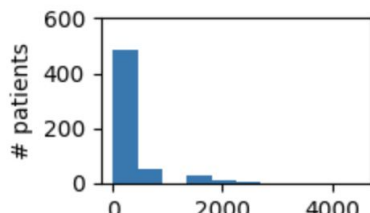
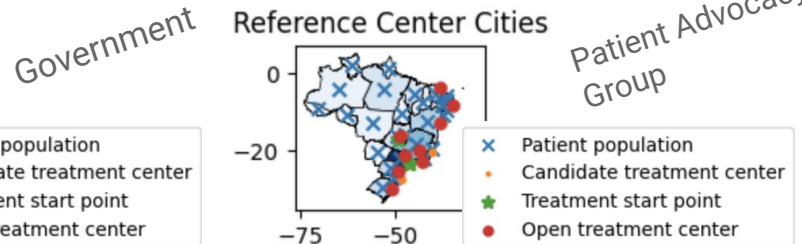
Centers: 1

PT costs: 2,431,950

TT costs: 25,397

Center costs: 100,000

HIGH patient travel



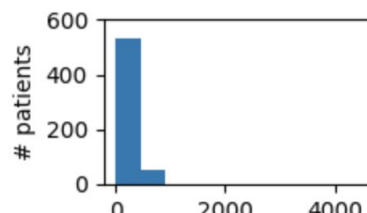
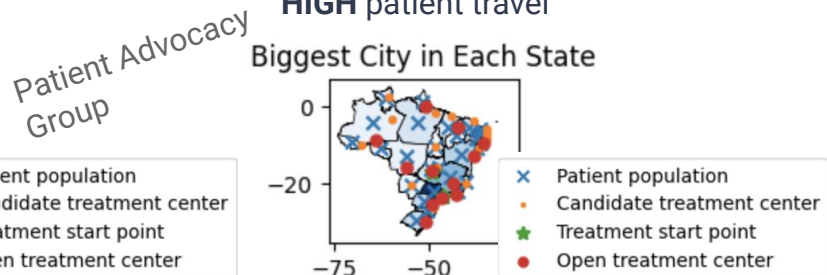
Centers: 9

PT costs: 857,354

TT costs: 802,318

Center costs: 900,000

HIGH patient travel



Centers: 12

PT costs: 622,115

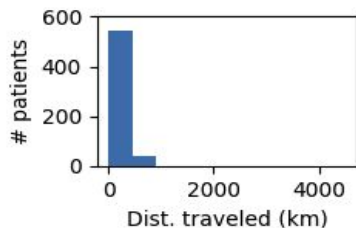
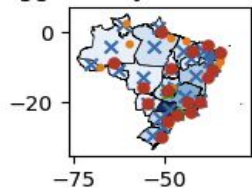
TT costs: 851,782

Center costs: 1,200,000

PAG preferences

Center: LOW
Patient: HIGH
Transport: MEDIUM

Biggest City in Each State



Centers: 17

PT costs: 551,407

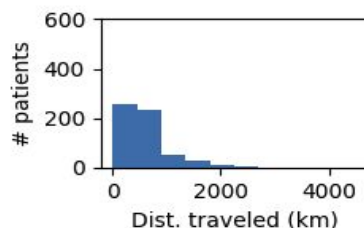
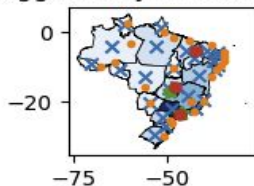
TT costs: 879,012

Center costs: 1,700,000

Middle ground exploration

Center: MEDIUM
Patient: MEDIUM
Transport: LOW

Biggest City in Each State



Centers: 3

PT costs: 1,355,308

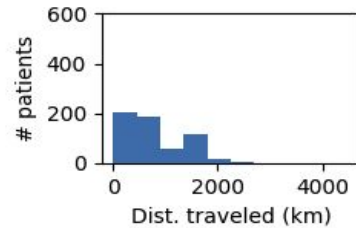
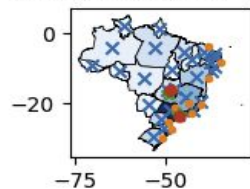
TT costs: 422,323

Center costs: 300,000

Government preferences

Center: LOW
Patient: LOW
Transport: MEDIUM

Reference Center Cities



Centers: 2

PT costs: 1,834,255

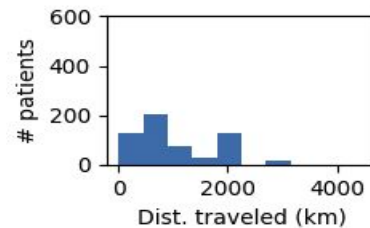
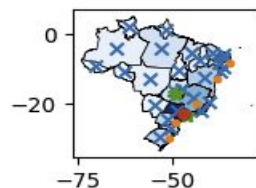
TT costs: 54,176

Center costs: 200,000

Pharma preferences

Center: HIGH
Patient: MEDIUM
Transport: MEDIUM

Previous GT Cities



Centers: 1

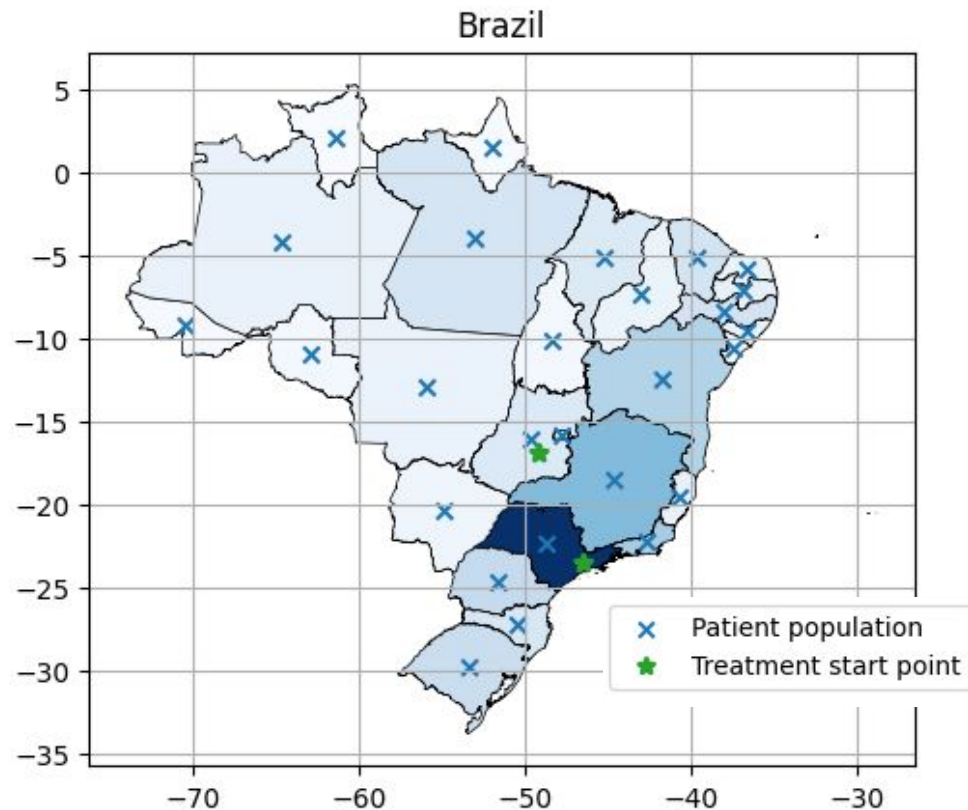
PT costs: 2,332,511

TT costs: 95,287

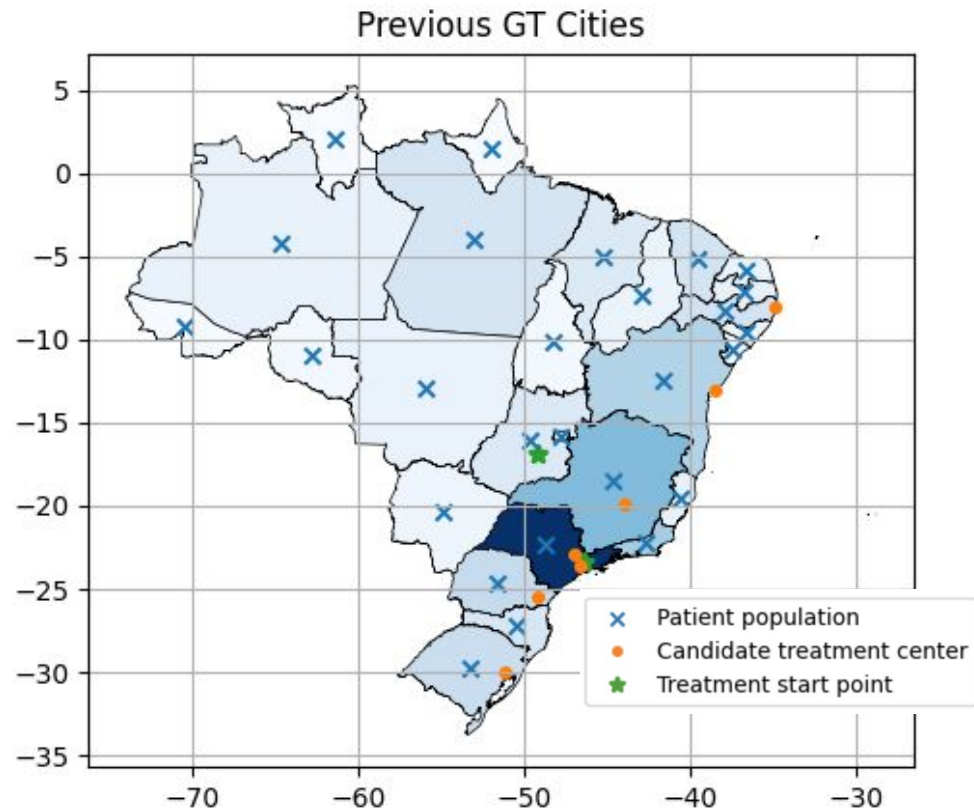
Center costs: 100,000

Appendix: Reference Maps

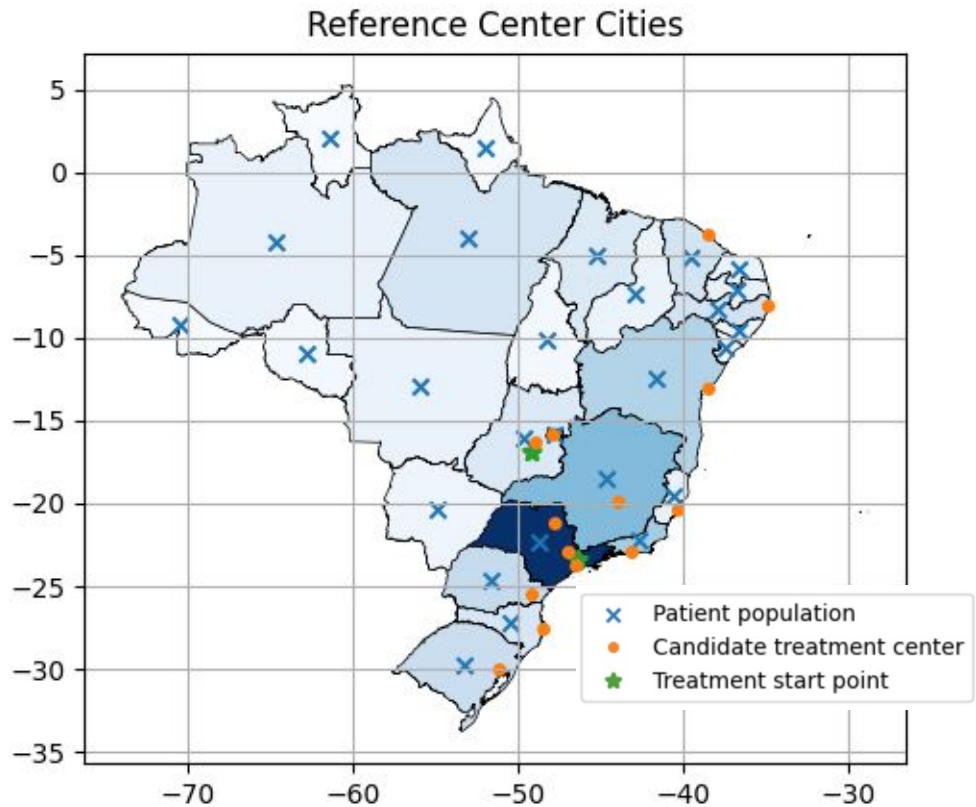




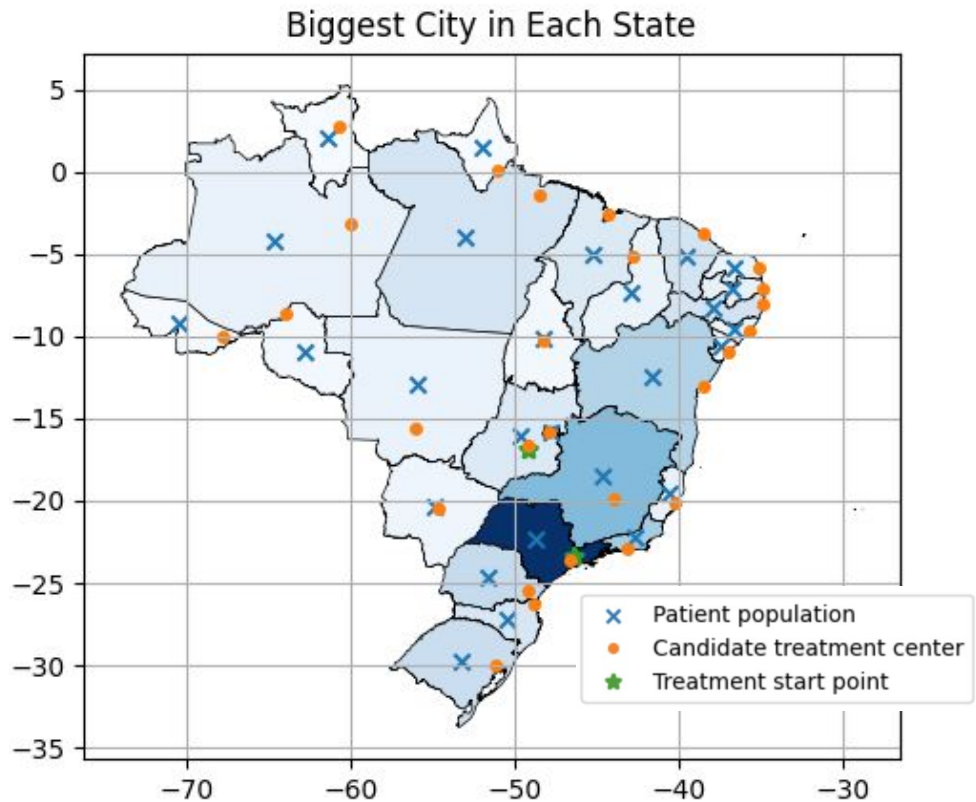
Treatment Start Points and Patient Populations



Previous Gene Therapy Treatment Center Cities



Reference Center Cities



Biggest City in Each State