MIT Center for Transportation & Logistics

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

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Project Overview

Project Blurb

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

2023

First year

Scoping
Background research
Initial modeling
Talking to global teams

Winter 2024

Trip to Brazil

Modeling iterations
Trip to São Paulo

Spring 2024

Finalizing and showcasing model

Feedback from Brazil team
Interactive workshop

Summer 2024

Final handover

Final deliverables
Thesis

Scope

Background on Brazil

Statistics:

- 3.3 million mi^2 / 8.5 million km^2 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 ≅ 0.2 USD
  - 5 BRL ≅ 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

2. Patient cost (cost per patient treated)

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

Not dependent on TC selection

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

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

Focus of my project

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

Approach definitions

Ex: *Centralize*
Center cost: HIGH
Patient travel: LOW
Treatment transport: MEDIUM
Options: 15 biggest cities

Treatment start points

GRU
GYN

Estimated patient populations

Census data & prevalence data

Center candidates

Biggest City in Each State

	City	Region
2	São Paulo	São Paulo
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22	João Pes	
23	Maceió	
24	Aracaju	
25	Serra	Espírito Santo
26	Joinville	Santa Catarina
27	Campo Grande	Mato Grosso do Sul
28	Cuiabá	Mato Grosso

15 Most Populous Cities

	City	Region
2	São Paulo	São Paulo
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

RD Reference Center Cities

	City	Region
2	Rio de Janeiro	Rio de Janeiro
3	Brasília	Distrito Federal
4		
5		
6		
7		
8		
9		
10		
11		
12		
13	Santo An	
14	Vitória	
15	Florianópolis	Santa Catarina

Previous GT Cities

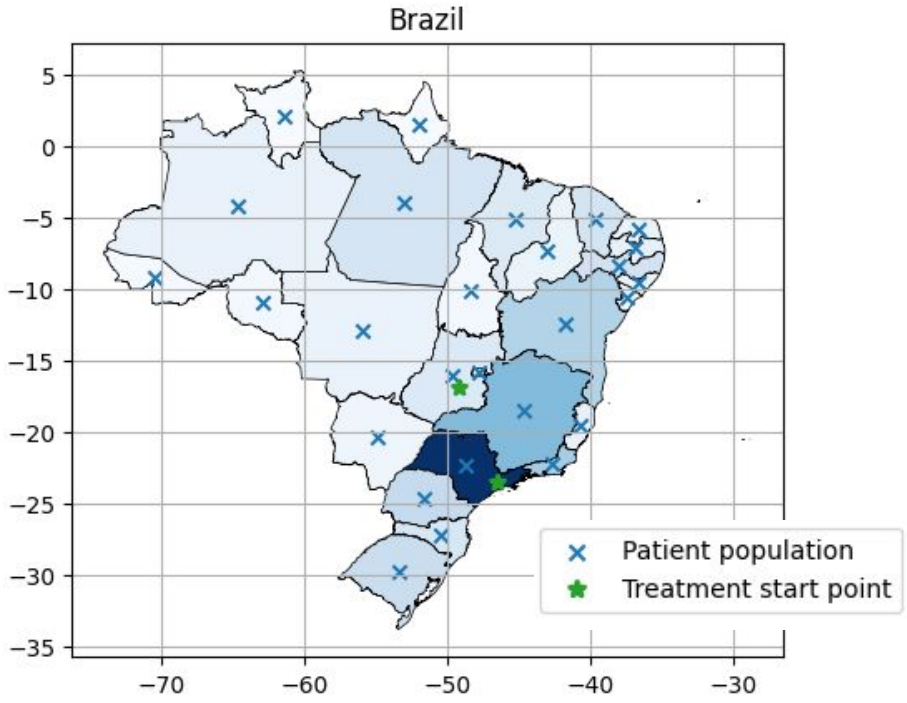
	City	Region
2	São Paulo	São Paulo
3	Salvador	Bahia
4		
5		
6		
7		
8		

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

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 Goiâna, 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

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

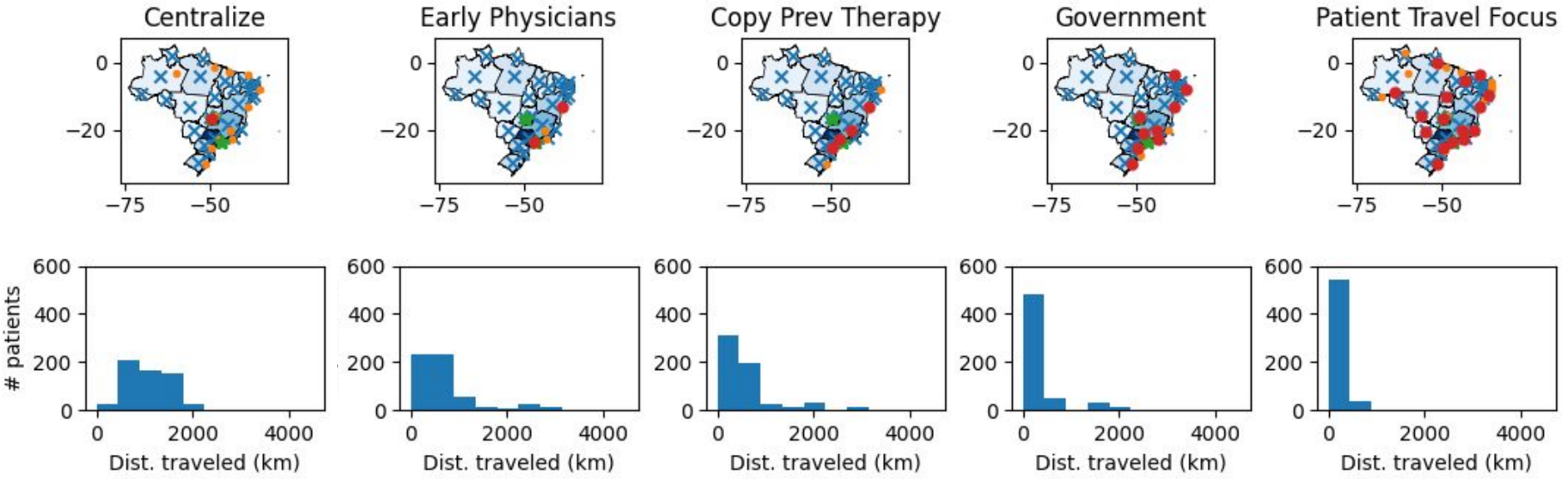
Priorities:
Center: MEDIUM,
Transport: LOW,
Patient: HIGH

Patient Travel Focus

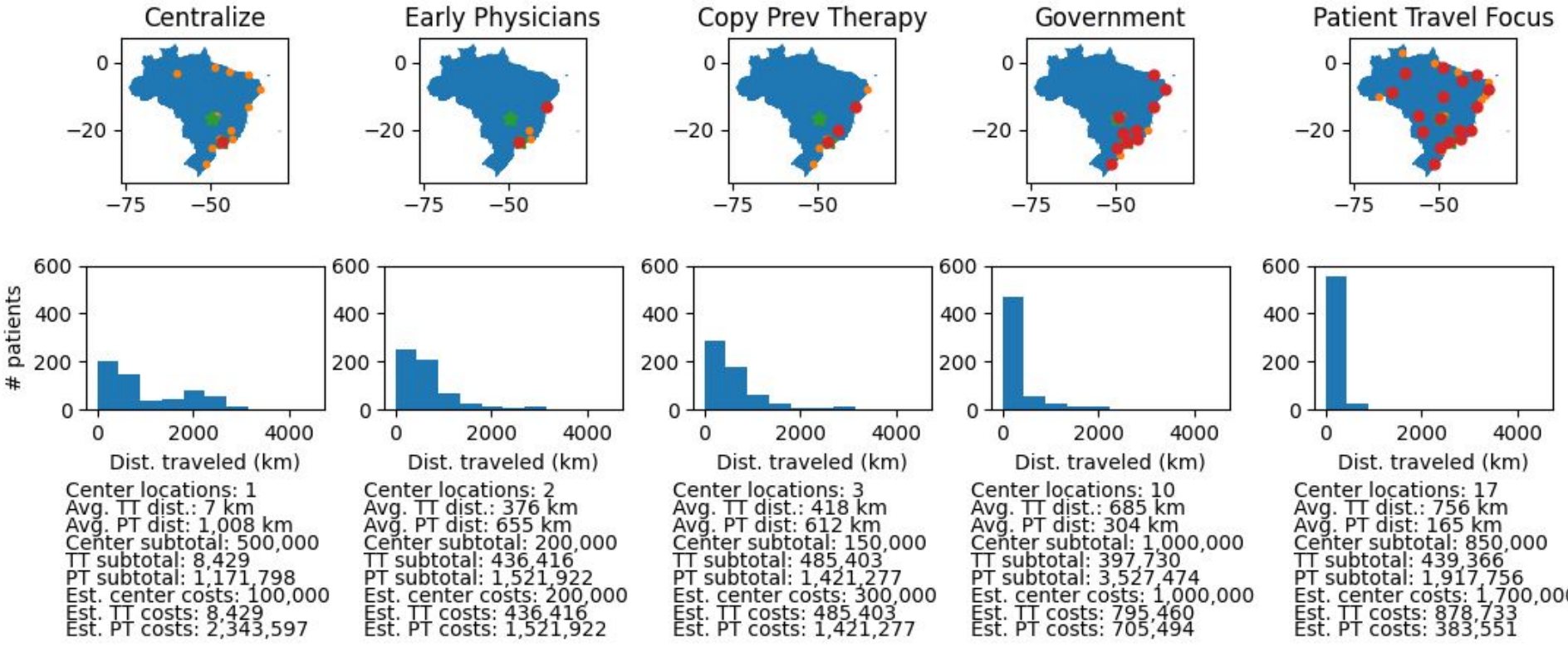
Strong focus on patient travel.

Candidate locations:
Biggest city in each state

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



State-level patient populations

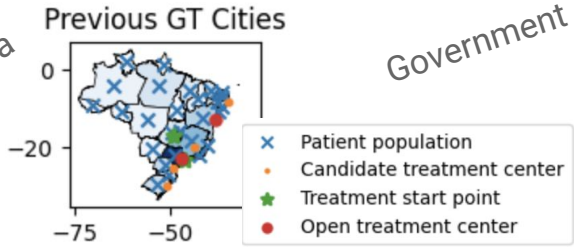


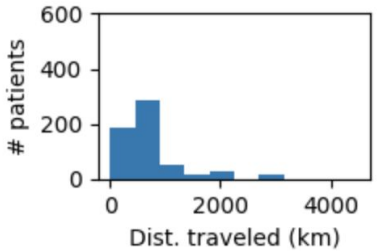
Municipality-level patient populations

Interactive Workshop Results

All Medium Priority (*pre-workshop*)

Pharma





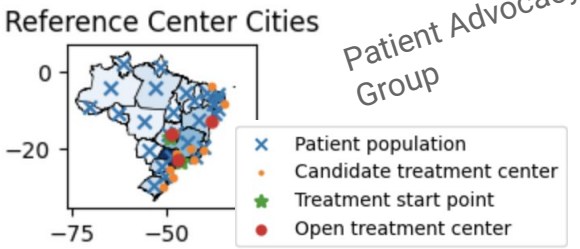
Centers: 2

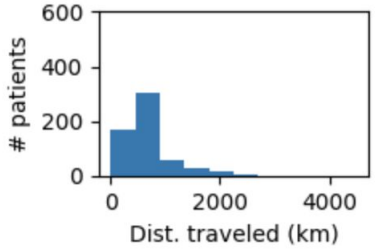
PT costs: 1,618,369

TT costs: 451,848

Center costs: 200,000

Government





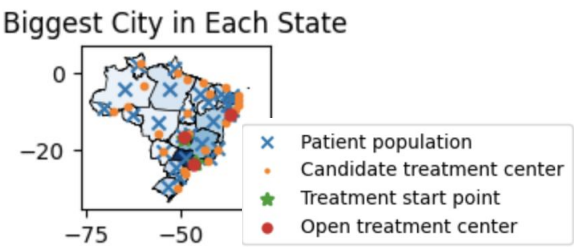
Centers: 3

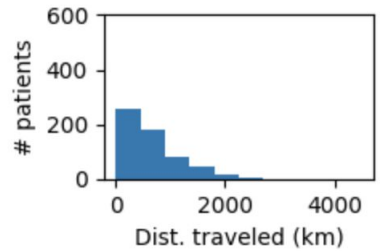
PT costs: 1,480,418

TT costs: 283,748

Center costs: 300,000

Patient Advocacy Group





Centers: 3

PT costs: 1,454,179

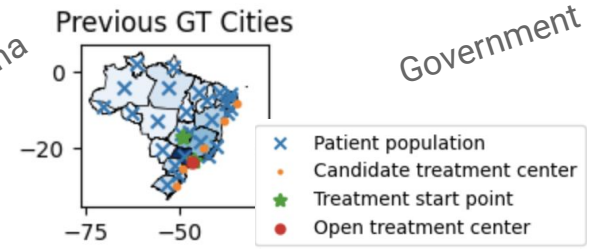
TT costs: 270,330

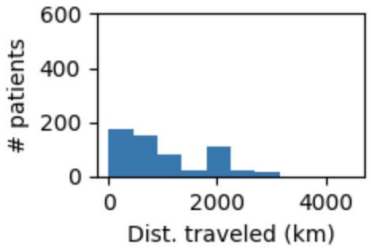
Center costs: 300,000

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

Pharma

HIGH treatment transport





Centers: 1

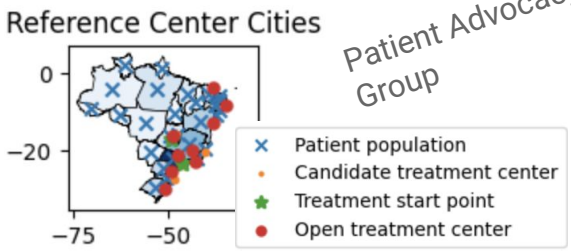
PT costs: 2,431,950

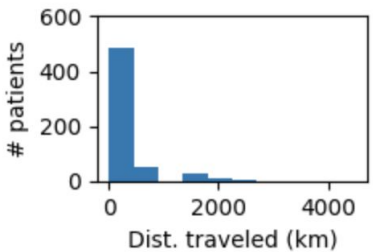
TT costs: 25,397

Center costs: 100,000

Government

HIGH patient travel





Centers: 9

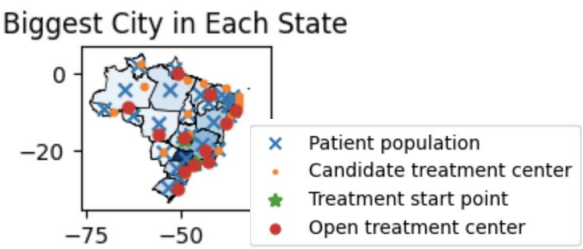
PT costs: 857,354

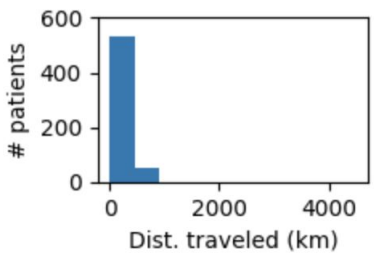
TT costs: 802,318

Center costs: 900,000

Patient Advocacy Group

HIGH patient travel





Centers: 12

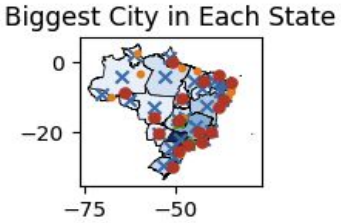
PT costs: 622,115

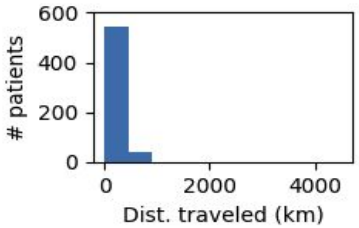
TT costs: 851,782

Center costs: 1,200,000

PAG preferences

Center: LOW
Patient: HIGH
Transport: MEDIUM





Centers: 17

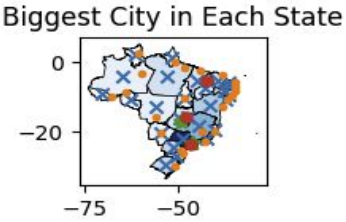
PT costs: 551,407

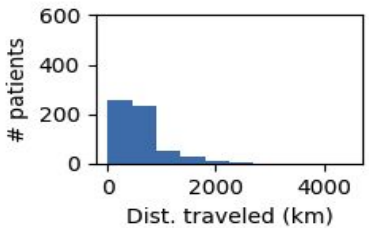
TT costs: 879,012

Center costs: 1,700,000

Middle ground exploration

Center: MEDIUM
Patient: MEDIUM
Transport: LOW





Centers: 3

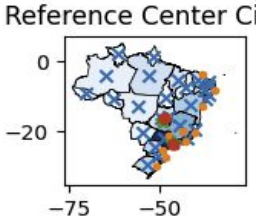
PT costs: 1,355,308

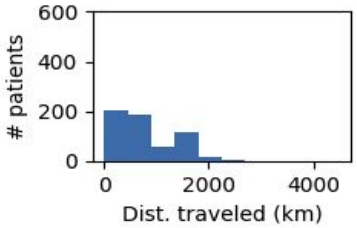
TT costs: 422,323

Center costs: 300,000

Government preferences

Center: LOW
Patient: LOW
Transport: MEDIUM





Centers: 2

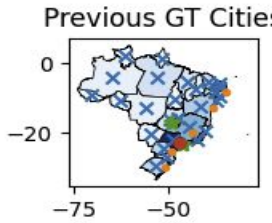
PT costs: 1,834,255

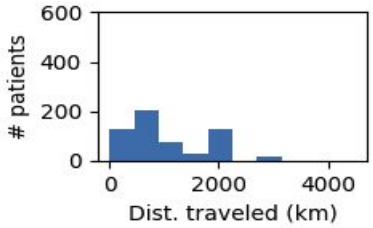
TT costs: 54,176

Center costs: 200,000

Pharma preferences

Center: HIGH
Patient: MEDIUM
Transport: MEDIUM





Centers: 1

PT costs: 2,332,511

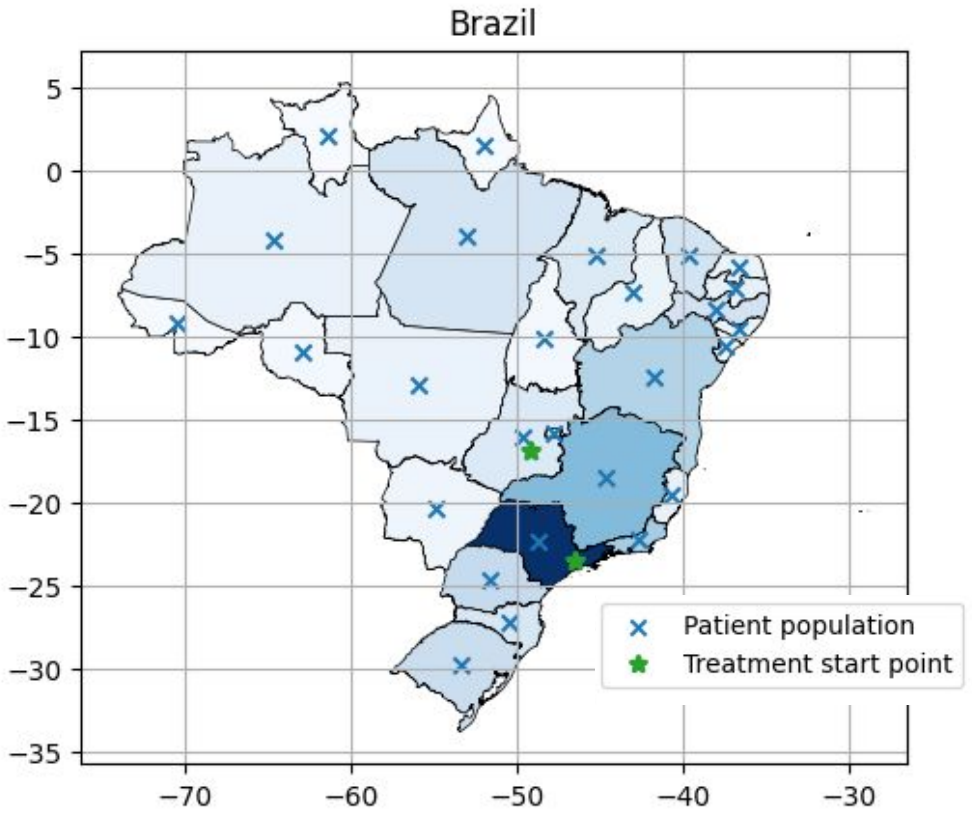
TT costs: 95,287

Center costs: 100,000

Workshop exploration and stakeholder roleplay

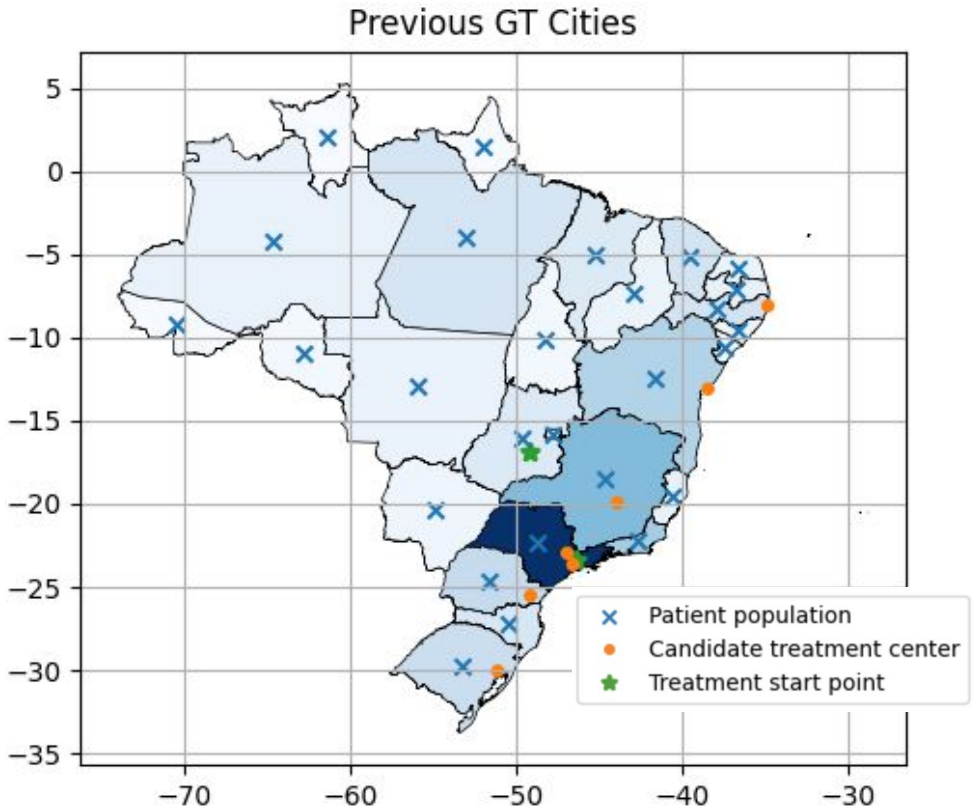
Appendix: Reference Maps

https://www.mappr.co/counties/brazil-states-map/



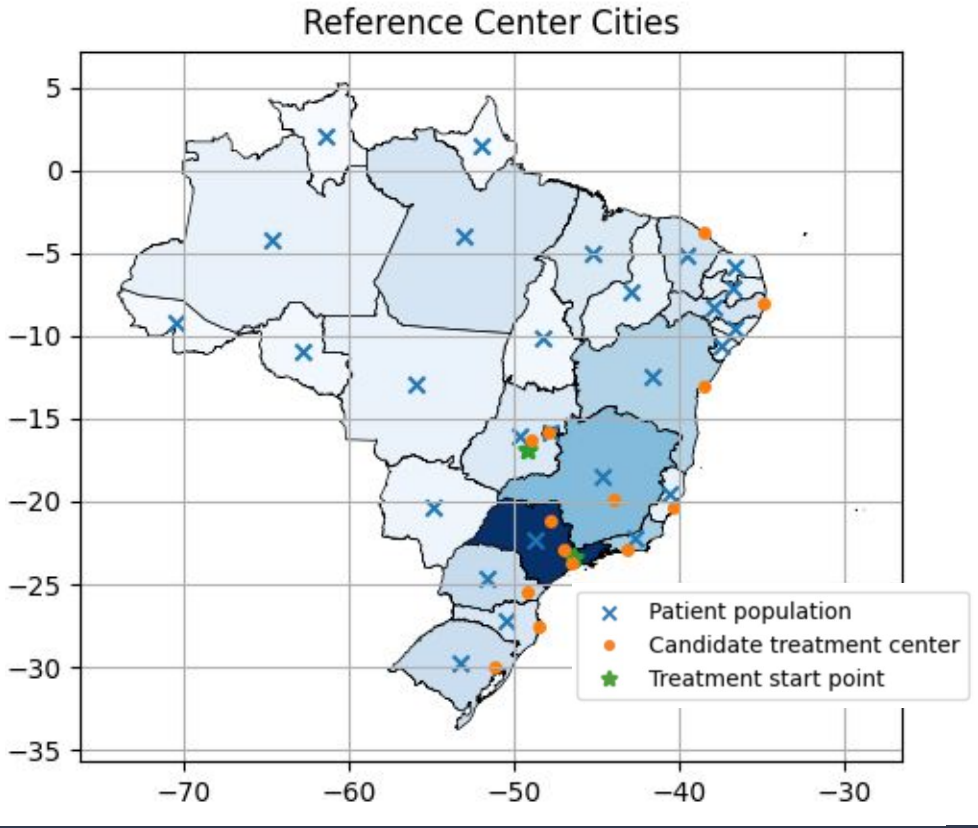
Treatment Start Points and Patient Populations

https://www.mappr.co/counties/brazil-states-map/



Previous Gene Therapy Treatment Center Cities

https://www.mappr.co/counties/brazil-states-map/



Reference Center Cities

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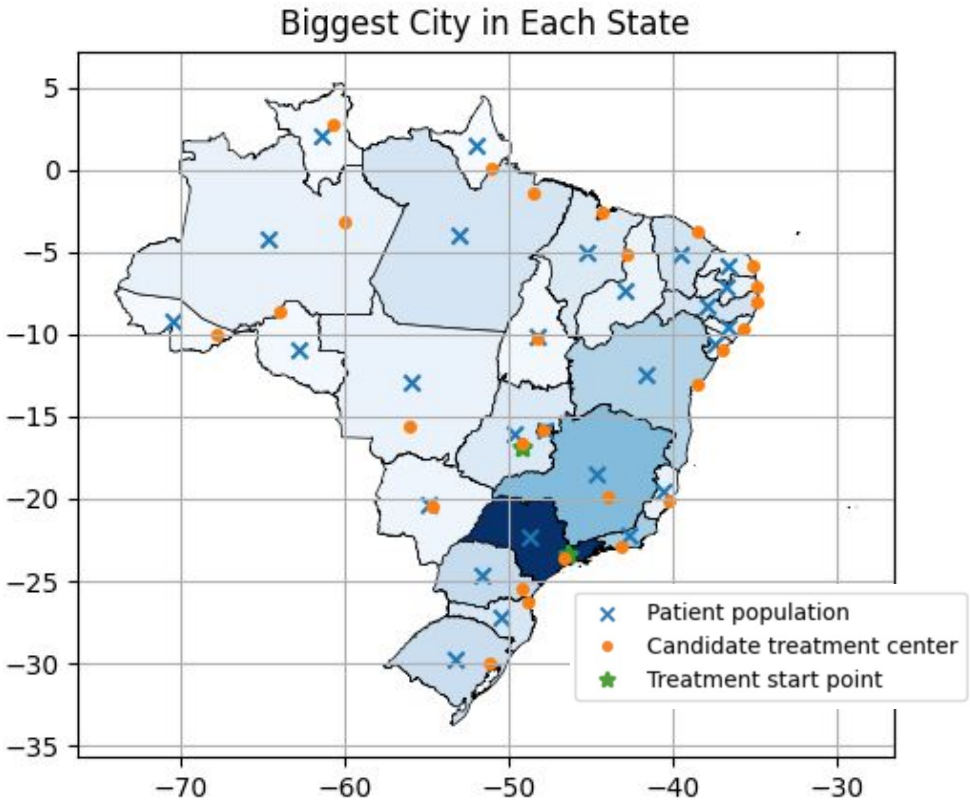

Biggest City in Each State