Identifying Hotspot for Mental Health Facilities

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Informs Annual Conference 2022

1. Introduction

- Serious mental health illness (SMI) is defined diagnosable mental, behavioral, or emotional disorders that causes serious functional impairment that substantially interferes with or limits one or more major life activities
- Diagnosis and ICD 10 Codes of SMI

Diagnosis	ICD 10 Codes
Schizophrenia	F20
Other non-affective psychosis	F22-F29
Bipolar disorder	F30, F31
Major depression	F32, F33
Other affective disorders	F34, F39

- Mental health treatment are usually the combination of therapy and prescriptions, including mood stabilizers (lithium, anticonvulsant medicines, and antipsychotic medicines), psychological treatment (psychoeducation, cognitive behavioral therapy, and family therapy), and lifestyle advice
- An estimated 7 million (49.7% of the diagnosed population) are perceived with unmet demand of mental health services nationally

Objective:

- Estimate the unmet SMI treatment at a census tract level
- Identify new mental health facility locations to maximize the number of new SMI patients can be served considering both geographic access and facility capacity

2. Methods

Notations and Decision Variables:

Notation	
U	The set of census tracts with currently unmet demand (capacity > c, or distance > r)
N	The set of potential new facilities
k	Number new facilities to open
u_i	Currently unsatisfied demand of tracts, $i \in U$
$d_{i,j}$	Distance from tract i to facility j,
c	The capacity of facilities (instead of assuming it on newly opened facilities, it is assumed to be an infinitely large number in the model)
r	The distance between new potential facilities and census tracts (set to be 30 miles in this work)
Variables	
$y_{i,j}$	Newly served SMI patients from tract i served by facility j, $i \in U$, $j \in N$
z_j	1 if we open the facility, $j \in N$

2. Methods

Optimization model: maximize the new potential SMI patients

$$\max \sum_{i \in U} \sum_{j \in N} y_{i,j}$$

$$subject\ to: \quad \sum_{j \in N} y_{i,j} \le ui, \forall i \in U \qquad (1)$$

$$\sum_{i \in U} y_{i,j} \le czj, \forall j \in N \qquad (2)$$

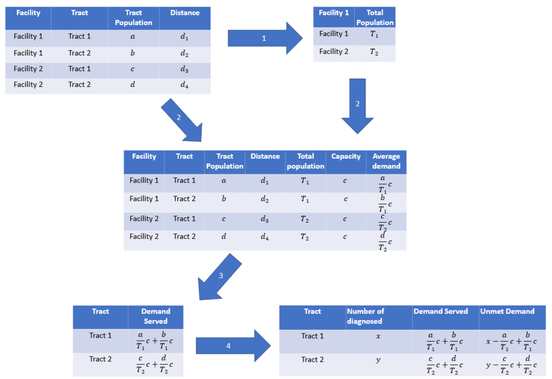
$$\sum_{j \in N} z_j \le k \qquad (3)$$

$$yi_{,j} = 0, \forall i \in U, \forall j \in N : di_{,j} > r \qquad (4)$$

$$y_{i,j} \ge 0, zj \in \{0,1\} \qquad (5)$$

- Constraint (1) says that the number of newly served SMI patients cannot surpass the number of people diagnosed with SMI that are perceived with unsatisfied demand in that tract.
- Constraint (2) enforces the new patients can only be served by new facilities. If $z_j = 0$, no demand can be served at facility j, if $z_j = 1$, the unmet demand in the range will be summed up
- Constraint (3) limits the number of locations that may be identified
- Constraint (4) indicates that new patients can only be served by the facility if the distance is within the threshold
- Constraint (5) ensures my continuous variable to be non-negative and z_j to be binary variable

Estimated unmet demand



3. Results

The distribution of the existing facilities and the number of diagnosed SMI patients in each different census tract

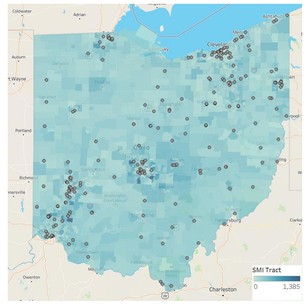


Figure 1: Existing facility locations and census tracts

- Most existing facilities are in Columbus, Cleveland, Dayton, and Cincinnati

Estimated demand served and unmet demand

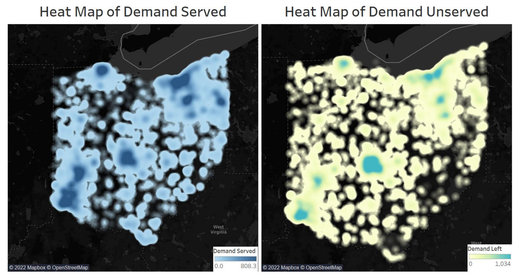


Figure 2: Heat map of demand served and unmet demand

- Even after accounting for existing facilities, the largest pockets of unmet demand exist in urban areas such as Columbus, Cincinnati, and Cleveland
- Statewide total demand served is 295,755
- The predicted unmet demand in Ohio is 469,549

The new potential facilities when k = 10

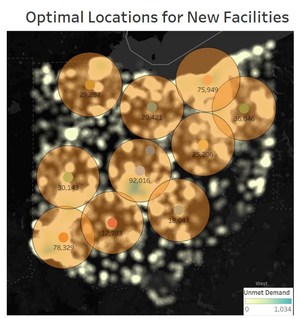


Figure 3: Optimal Locations for New Facilities

- 21% of Ohio unmet demand is covered within the geographic coverage of 1 new facility and 59.8% is covered within 3 facilities
- No facilities presented in the center of Columbus, the patient flows are assigned to 3 nearby locations
- Rural areas are covered by the new facility locations
- The greedy solution is not system wide optimal - different locations are picked for different values of k
- As expected, we see decreasing marginal returns in the number of patients served by each facility with more facilities opened(larger k)

3. Results

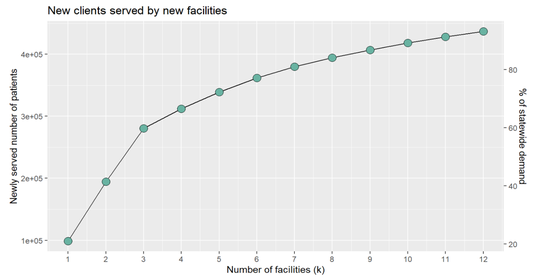


Figure 4: New clients served by new facilities

4. Discussion/Conclusion

- 65,304 people have diagnosed with serious mental illness, which is about 6.55% of the total population in Ohio.
- Among the 765,304 people with SMI, 469,549 (61.4%) are estimated with unmet demand of mental health treatment due to the lack of geographic access or facility capacity, while it is reported that 49.7% (about 7 million people) were perceived unmet demand for mental health services among the 14.2 people with SMI.
- The 10 new possible facility locations can serve up to 418,228 new SMI patients, which is about 89.1% of predicted unsatisfied demand in Ohio

Limitations:

- We have assumed that the new potential mental health facilities can only be opened at the center of census tracts
- We have assumed the new facilities can serve all the demand from the 30-mile range, in other words, there is no facility capacity

5. Acknowledgements

This project was funded by the William G. & Mary Ellen Bowen Research Endowment at Denison University, with additional support from Data Analytics Department at Denison University. I really appreciate assistance from Dr. Anthony Bonifonte for guiding me through this research project

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