OPERATIONS RESEARCH FOR FAMILY VIOLENCE NEEDS ASSESSMENT IN THE STATE OF GEORGIA

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ABSTRACT

We detail the background, OR methodology, and practical results from a needs assessment of domestic violence services completed for Georgia's Family Violence Unit. We created a mixed-integer optimization model to balance the geographic distribution of shelters and supply of shelter beds with the demand for services. The impact of various distance constraints and capacity restrictions were studied. Results from the model, and application of the results within the FVU, will be discussed.

BACKGROUND

Domestic violence is a serious problem both nationally and within the state of Georgia. Studies show that 1 in every 4 women will experience domestic violence in her lifetime and between 3.3 and 10 million children witness some form of domestic violence annually. Witnessing violence between one's caretakers is also the strongest risk factor of transmitting violent behavior from one generation to the next. [2] Domestic violence continues to be a leading cause of injuries for girls and women between the ages of 15 and 44 in the state of Georgia. [2] In Georgia, at the time of this study, the Family Violence Unit (FVU) fell under the Division of Family and Children Services (DFCS) in the Georgia Department of Human Resources (DHR).

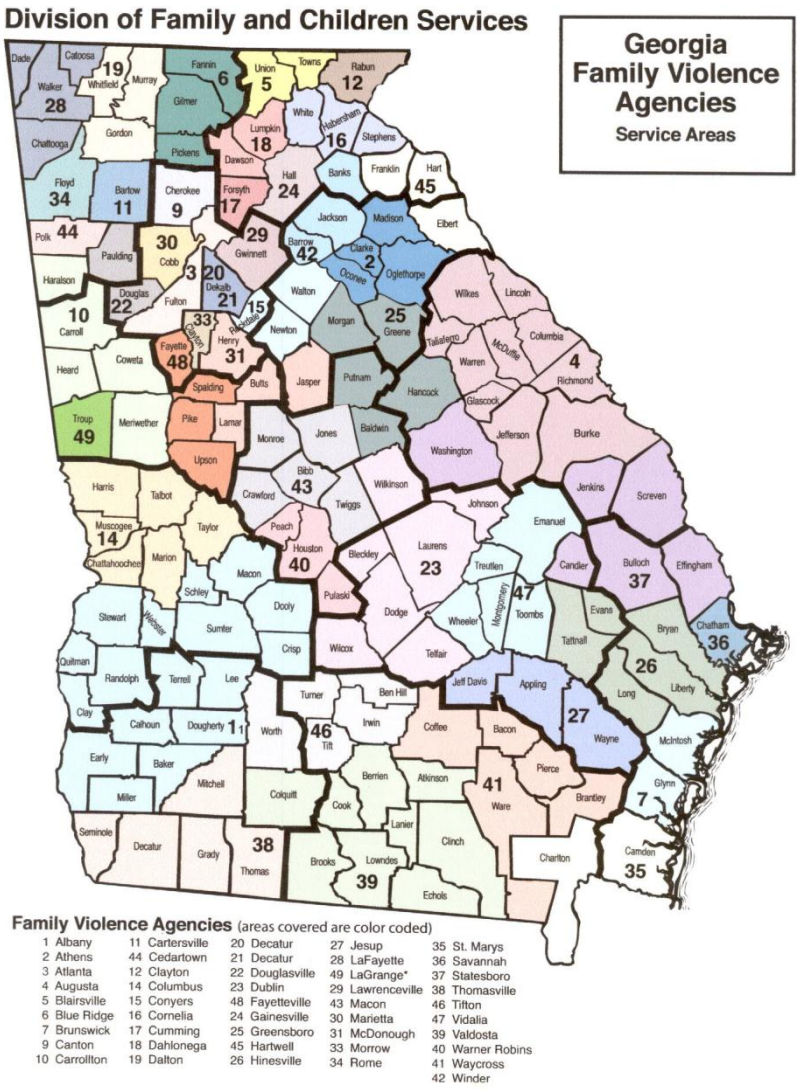
FVU funds a statewide network of 45 certified domestic violence shelters providing both shelter and outreach services and one additional shelter providing only outreach services. Shelter services are defined as all of the services provided to family violence victims who are physically housed in the shelter. Outreach services are similar services provided to victims living in the community who are not housed in the shelter. The shelters are operated by private, nonprofit organizations, and provide 24-hour crisis lines; legal and social service advocacy; children's programs; parenting support and education; emotional support; household establishment assistance; follow up services and community education. All of the services are free and confidential. The service area for each shelter is defined geographically by county, with each of Georgia's 159 counties assigned to exactly one of the 45 shelters that provide shelter services. This current allocation is illustrated in Figure 1. [4] The bold numbers on the map are shelter locations, and the shading represents the counties assigned to that shelter. In 2006, these certified family violence agencies received 96,110 crisis calls and sheltered 4,588 adult and 4,788 child victims of family violence. [2]

Due to budget pressures and perceived differences between the effectiveness of various shelters, FVU needed a more concrete method to determine geographic placement of shelters in Georgia to meet the demand for family violence services. In particular, the needs assessment was commissioned to answer two questions:

(1) Are certified violence shelters in Georgia geographically placed to meet the domestic violence needs of Georgians? If not, where are there gaps?
(2) Within Georgia's network of violence shelters, what is the optimal mix of shelter versus outreach services' locations to best meet the needs of Georgians?

In order to answer these questions, the authors created a mathematical model to balance the geographic distribution of shelters or supply of shelter beds with the demand for family violence services. The model and results are detailed below.

Figure 1: Location of Family Violence Agencies in Georgia



OPTIMIZATION MODEL

As is typical of not-for-profit scenarios, a basic cost minimization or profit maximization objective was not appropriate for this problem. Primary concerns from FVU included equitability of the solution (not favoring one geographic region of the state over the rest), the need to not deviate significantly from the current network, and capacity benchmarks. FVU was also especially interested in being provided a range of solutions. If closing several different shelters would provide near-optimal solutions, this information would allow them the flexibility to factor shelter performance and political issues into their decisions.

Data and demand

We first estimated the county-level demand for services. Available relevant data included:

- Law enforcement data: incident-based family violence data and temporary protection orders (TPO) data available through the Georgia Bureau of Investigation (GBI) reported by county in calendar year 2006. [1]
- Hospital data: the number of visits (all hospital admissions and ER visits) with an intentional injury diagnosis available through the Georgia Hospital Association (GHA) reported by county in calendar year 2006. Diagnosis was defined using ICD-9 (International Classification of Diseases, Ninth Revision) codes for intentional injury in the range of E960-E969: "homicide and injury purposely inflicted by other persons". All intentional injury visits were used as proxies for violence in a community rather than any codes specific to the type of perpetrator or victim. [3,7]
- Georgia Division of Public Health data: drug overdoses (defined as the misuse or overuse of any medication or drug, including alcohol and tobacco) from the OASIS database. [6]
- Census data: county-level population estimates, percentage of the county population living in poverty, percent Caucasian, percent male, and percent of births to unwed mothers.
- FVU programmatic data: the number of crisis center calls fielded per county and the number of bednights provided to victims by service region (shelter) available through monthly administrative data collected by FVU in calendar year 2006.

Running regression models on the available data in Minitab, the most important predictors of county-level need for domestic violence services per person were determined to be intentional injury hospital visits per capita, percentage of the population living in poverty, number of TPOs issued per capita, and an indicator for whether or not a shelter is currently in the county. Using results applied to Census data, local county-based estimates of demand were obtained, using similar methods to Griffin, Scherrer, and Swann. [5] These demand estimates were then included in the geographic optimization model to produce the results discussed in the following section.

Equitability

An equitable solution would provide similar service levels for each geographic region across the entire state. For that reason, we chose an objective function that would maximize the minimum percentage of demand served across all counties. However, equitability also needs to consider the distance that victims would need to travel to receive services. While demand is currently relatively low in some of the more distant counties, based on insights from the statistical model used to predict demand, demand may increase significantly if new shelters are added in closer proximity to these counties. This suggested that distance from a shelter does impact the service seeking patterns of victims. Choosing the distance constraint is not trivial. In areas without public transportation, the victim may or may not have access to transportation. Also, travel times can vary significantly based on the type of road. Through discussions with FVU it was determined that a 30-mile distance from center of a resident's county to the center of the county containing the shelter would be a reasonable targeted maximum distance, though we also looked at some 40 mile instances, as explained below.

Deviations from current network

Reasonable solutions to the problem could not involve completely recreating the network. FVU was interested in the results that could be achieved by opening a small number of additional shelters and by closing the residential component of a small number of current shelters; switching their focus over to

outreach only. Therefore, we considered combinations that included opening up to five additional shelters and converting up to ten current shelters to outreach.

Capacity

Current shelters range from 8 to 52 beds, in addition to the one location that offers outreach services only (no beds). We discussed with FVU that, when considering a capacity goal, program officials and policy makers should weigh the need to maximize the number of full beds while minimizing the number of clients refused services due to capacity constraints. This balance is difficult to achieve when trying to set capacity goals for a network with variability in shelter size, variability in family size, and timing of need. Through conversations with FVU staff and a review of preliminary results, the shelter capacity goal was set at 75 percent for most of the models in this report to best balance the aforementioned competing goals and ensure realistic expectations for the smaller, non-metro shelters.

The model

As mentioned above, we chose to model the problem with an equitability objective – maximizing the minimum fraction of the county's demand served. The optimization model is as follows:

Notation:

Indices:

i =index of demand nodes (centers of all counties in GA)

j =index of all potential shelter locations (centers of all counties in GA)

Decision variables:

x_{ij} = fraction of county i demand served in county j

y_{ij} = 1 if county i is assigned to a shelter in county j; 0 otherwise

s_i = 1 if there is a shelter located in county i; 0 otherwise

Data:

d_i = demand in county i in bednights

c_j = capacity of shelter in county j in bednights

D_{ij} = distance from demand node i to potential shelter location j, in miles

SM = maximum number of shelters allowed

DM = maximum distance allowed between counties for assignment
(set to the maximum of the distance to the closest shelter and the 30 or 40 mile target distance)

$$\max \ (\min x_{ij}) \qquad (1)$$

$$s.t. \ \sum_j y_{ij} = 1 \quad \forall i \qquad (2)$$

$$0 \le x_{ij} \le y_{ij} \quad \forall i,j \qquad (3)$$

$$y_{ij} \le s_j \quad \forall i,j \qquad (4)$$

$$y_{jj} = s_j \quad \forall j \qquad (5)$$

$$\sum_i x_{ij} d_i \le s_j c_j \quad \forall j \qquad (6)$$

$$\sum_j s_j \leq SM \quad (7)$$

$$y_{ij} D_{ij} \leq DM \quad \forall i,j \quad (8)$$

$$s_j, y_{ij} \in \{0,1\} \quad \forall i,j \quad (9)$$

Constraint (2) ensures that every county is assigned to exactly one shelter. Constraints (3) and (4) ensure that demand from counties is only assigned to open shelters, and constraint (5) requires that if a shelter exists in a county then the residents of that county are assigned to it. Constraint (6) is the capacity constraint and constraint (7) caps the number of shelters that can be opened. Constraint (8) requires that no one travel farther than the maximum pre-determined distance. Constraint (9) is the integrality constraint.

RESULTS

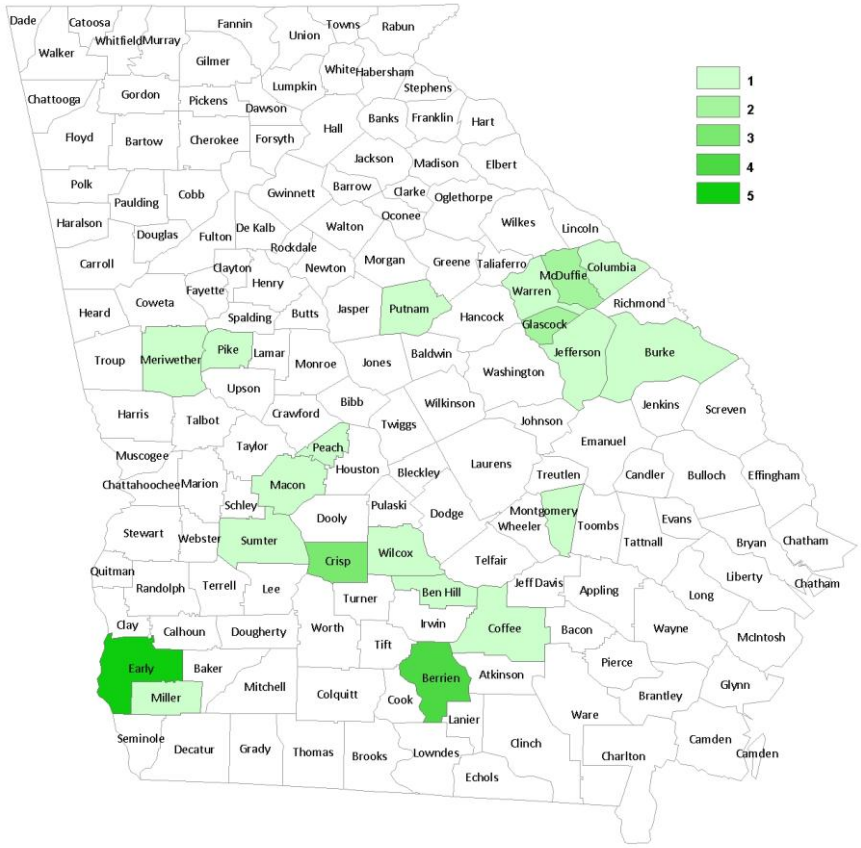
Current network

We first analyzed the current network. Without the addition of a distance constraint, the current network of shelters adequately meets the need for domestic violence services statewide, except for a few counties – mainly in the metro Atlanta area – that currently have their own shelters, but not enough capacity in that shelter to serve the demand in that home county. Due to the firm requirement that each county be assigned to exactly one shelter, the only way to fix that problem is by adding capacity to those shelters, so we gave FVU that list. Then, to avoid infeasible solutions for the rest of the analysis, *the capacity constraint in that subset of counties was set to allow the exact predicted demand from that county.*

While network capacity is acceptable in the state overall, there are significant problems with the distance many victims currently need to travel to reach their assigned shelter. In the current network, 40 counties (25.2% of Georgia's counties) are assigned to shelters more than 30 miles away (center of resident's county to the center of the county containing the shelter) and 19 counties to shelters more than 40 miles away. Twenty-four counties are more than 30 miles away from the *closest* shelter (which they may or may not currently be assigned to) and 6 are more than 40 miles from their closest shelter. Because of this, it is not possible to create a solution in the current network where no county's victims travel more than 40 miles. In addition, in a solution where counties can be assigned more than 40 miles away only if they are being assigned to the closest shelter, there would be insufficient capacity at the shelters in the southernmost part of the state. However, because of the excess capacity in the northern part of the state, several shelters (at least 5) could be switched to outreach without impacting the overall service level of the state. Similar results are found with a maximum distance of 30 miles, as opposed to 40.

Opening new shelters is one way to solve the distance problem, and generate solutions that satisfy the desired equitability constraints from FVU. If 5 shelters are switched to outreach and then 5 additional ones opened (keeping the total number of residential shelters constant) a network can be designed with a maximum distance of 30 miles and all demand satisfied. In addition, demand is currently very low in some of the counties that are quite far from current shelters. Based on our insights from the regression model mentioned above, that demand is likely to increase significantly with shelters added in those regions.

Figure 2. Counties the Model Chose to Place Additional Family Violence Shelters



Adding shelters

In order to identify general areas of the state in need of additional shelter services, multiple scenarios of adding shelters to the model were run, using both the 30 and 40 mile distance constraints. We ran scenarios ranging from adding one to five shelters to both the current network and to a network that switched five shelters to outreach at the same time. Results are displayed in Figure 2 by the number of times a county was chosen to receive a new shelter. The darker the color of the shaded county, the more times it was chosen by the model as a county that may be in need of additional shelter services.

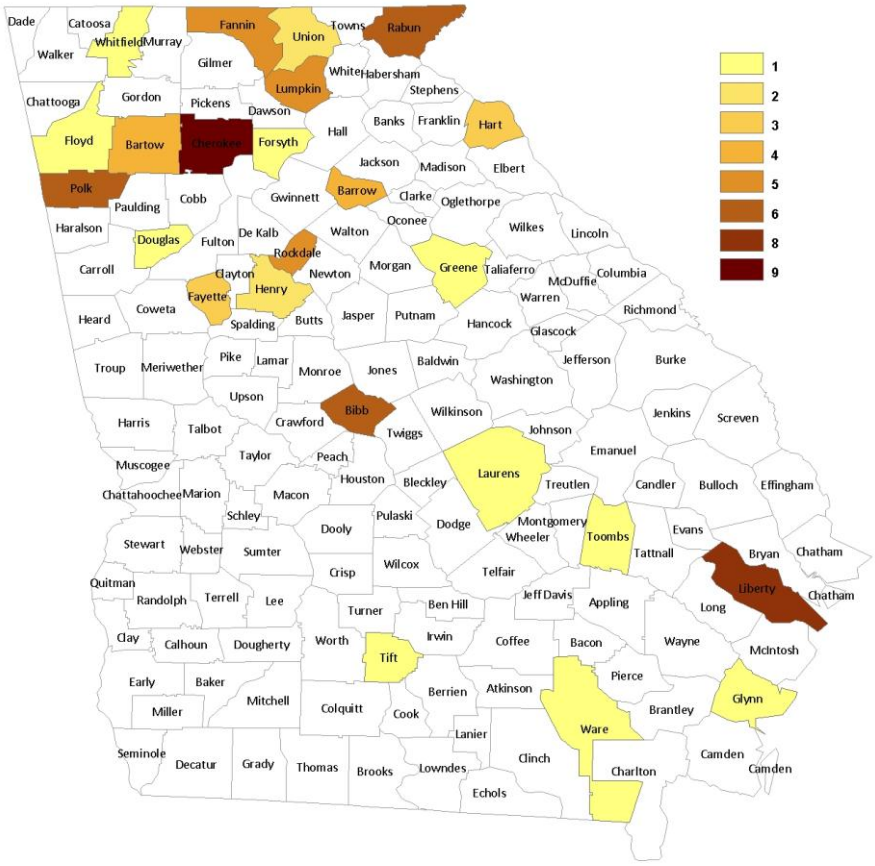
We found that there is strongest need for additional shelters in the southwestern part of the state based on distance, not demand, though locating a shelter there would also likely increase the demand for services, as mentioned above. There is also a need in the more central southern part of the state. This is from a combination of distance and demand. If we reassigned every county to their closest shelter, the shelter in Ware County would be over capacity. Finally, there is a need for an additional shelter in the central eastern portion of the state. This one is also capacity-driven because if all the counties in that region were assigned to Richmond County that shelter would be too full.

Switching shelters to outreach

FVU was also interested in evaluating whether there was an excess of shelters in certain regions of the state. This question was answered in a similar manner to identifying areas of additional need. Multiple

scenarios were run to identify areas of the state with excess capacity, ranging from shifting 1 to 10 shelters to outreach, while adding 0 to 5 shelters. Results were mapped in Figure 3 by the times a shelter was shifted to outreach by the model. In Figure 3, the darker the color the county is shaded, the more often it was chosen by the model to shift to outreach services. Several shelters (at least five) could be switched to outreach without impacting the overall service level. In general, there is excess capacity in the northern part of the state, specifically in the arc above the northern suburbs of Atlanta, and in the northeastern area. There is also excess capacity in the southeast, with four shelters currently in the counties along the coast.

Figure 3. Counties the Model Chose to Shift to Outreach Services



CONCLUSIONS

This work illustrates an excellent opportunity for operations research to serve the public sector. FVU had a problem that was adaptable to mathematical modeling, but often organizations that are not familiar with modeling are hesitant to blindly trust models. By providing them a set of robust solutions and explaining the patterns that we found, we were able to foster trust in the modeling process. The solutions were presented in a way that preserved their ability to use important, but subjective, knowledge to make the final decisions.

Future work

In future research, it would be interesting to consider multi-criteria decision making into the model to factor in issues of shelter performance and other preferences for which shelters are switched to outreach. In addition, FVU noted that the shelters work closely with the judicial system. Some judges are frustrated by working with multiple shelters that are in many cases assigned to the same judicial circuit. For that reason, it might be helpful to take judicial circuits into consideration in shelter allocation decisions in the future.

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