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Staffing Efficiently in NorthShore University HealthSystem Gastroenterology Lab in Evanston

Problem Statement and Scope

NorthShore needs a financially efficient staffing method for the nurses and lab technicians in the GI Unit

- NorthShore is experiencing cost and time inefficiencies
- Nurses' and lab techs' schedules vary with patient demand

Objective: Create a streamlined staffing model that minimizes costs

- Our linear program uses robust optimization
- We use an ellipsoidal uncertainty set to account for fluctuations in the demand and staff efficiently

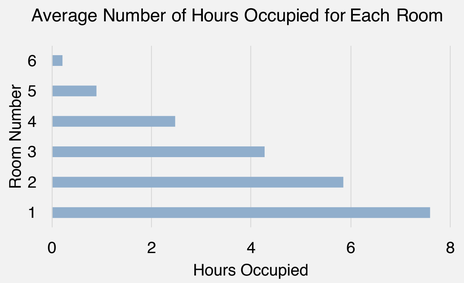
The Data

Room Utilization
- By hospital, hour, day of the week, month

Employee Costs
- Varies by employee type and includes fringe

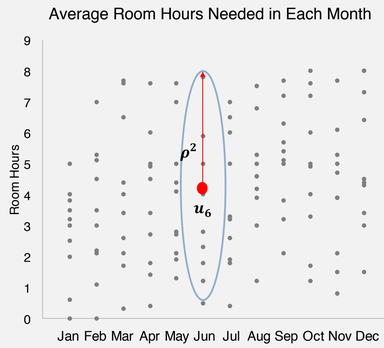
Hours of Operation
- Varies by location and time of year

Data Transformation
- Data manipulated to help staff by occupied procedure rooms per hour



- We transformed the data from individual patient check-in times per hour to hours occupied per room
- Justification: limiting constraint for our staffing model will be room availability

Ellipsoidal Uncertainty



Data Dependent Model

Sets:

j: {1, 2, 3}, employee type where the numbers correspond to full-time, part-time and resource nurse, respectively

k: {1, 2, 3, 4, 5, 6}, room number

Parameters:

u_k: Uncertainty of room k, where $u_k = b_k - \mu_k$

Σ: Covariance matrix of b_k

ρ^2: Tuning parameter for uncertainty based on χ^2-dist.

c_j: Cost of employee type j

$A_{j,k}$: Staffing efficiency matrix for each employee type j, corresponding to rooms used k

r_k: Room to nurse ratio for room k, scalar

b_k: Utilization (hours) of room k for each day of the week in each month for each given year, scalar

Decision Variable:

$x_{j,k}$: Staffing vector in which each row corresponds to the number of employee type recommended for each room k

Find Uncertainty Vector:

$$\max \quad u_k \rightarrow u_k^* \qquad \forall\, k$$
$$\text{s.t} \quad u_k^T \Sigma^{-1} u_k \leq \rho^2 \qquad \forall\, k$$

Solve Robust Linear Optimization Model:

$$\min \quad \sum_{j=1}^{3} \sum_{k=1}^{6} c_j^T x_{j,k}$$
$$\text{s.t} \quad \sum_{j=1}^{3} A_{j,k}\, x_{j,k} \geq r_k (b_k + u_k^*) \qquad \forall\, k$$

Limitations

- Resource staff not modeled; lowest cost and allows to decouple the hospitals in order for a timely completion
  - Resource staff have the lowest hourly wage of any staff type which indicates that all resource staff should utilized to its maximum capacity
- The coupled model would be similar, just with an additional sum over hospitals
  - Optimization model applies only to the Evanston location; number of rooms optimized for may vary for other hospitals based on demand and capacity constraints
- Weekend demand is very variable and robust solution would be too conservative, hence we excluded it from consideration
  - Variability in weekend hours throughout the year due to seasonality constrained our model's ability to optimize staffing

Our Recommendation (FT, PT)

	Mon	Tues	Wed	Thurs	Fri
Jan	(5, 9)	(6, 3)	(4, 4)	(7, 3)	(5, 3)
Feb	(7, 3)	(6, 2)	(5, 3)	(7, 3)	(5, 4)
Mar	(10, 0)	(7, 1)	(5, 3)	(7, 3)	(7, 2)
Apr	(6, 4)	(9, 2)	(5, 3)	(6, 3)	(5, 3)
May	(4, 4)	(9, 1)	(6, 2)	(5, 4)	(7, 1)
Jun	(9, 1)	(8, 2)	(6, 2)	(6, 2)	(6, 3)
Jul	(9, 2)	(9, 2)	(6, 4)	(8, 2)	(6, 2)
Aug	(6, 3)	(6, 5)	(5, 3)	(6, 3)	(6, 2)
Sep	(7, 3)	(8, 2)	(6, 2)	(8, 3)	(7, 2)
Oct	(10, 1)	(6, 4)	(5, 3)	(7, 3)	(6, 2)
Nov	(10, 0)	(9, 1)	(6, 2)	(7, 2)	(5, 3)
Dec	(7, 3)	(7, 3)	(5, 3)	(6, 3)	(5, 3)

- Resource staff can be utilized to compensate for inconsistencies in staffing throughout any given week by replacing full-time and part-time nurses, where needed
- These staffing complement ratios would translate to other hospital locations

Next Steps

- Incorporate resource staff into robust linear optimization model
- Perform analysis for all locations with with their own demands and constraints
- Accommodate for the different complexities of weekend demand

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- TA: Abhik Bera

References

Bertsimas, Dimitris, David B. Brown, and Constantine Caramanis. "Theory and Applications of Robust Optimization." SIAM Review 53.3 (2011): 464-501.

Green, Linda V., Sergei Savin, and Nicos Savva. ""Nursevendor problem": Personnel staffing in the presence of endogenous absenteeism." Management Science 59.10 (2013): 2237-2256.

Shi, Pengyi, et al. "Models and insights for hospital inpatient operations: Time-dependent ED boarding time." Management Science 62.1 (2015): 1-28.

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