# Balancing Hospitalist Workload by Optimizing Patient Assignment using Linear Programming


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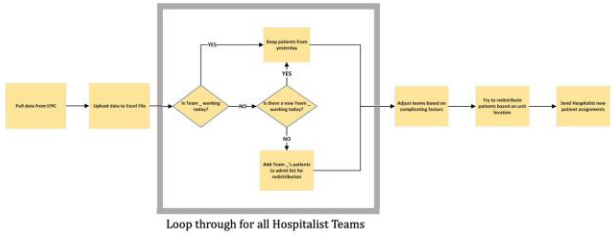
## Parkland Memorial Hospital

Parkland Health and Hospital System serves the 2 million people of Dallas County, Texas, with one hospital, twenty community clinics, and twelve school-based clinics. The hospital (we refer to the hospital as Parkland) is approximately 2.8 million square feet, has about 900 beds, and has an annual operating budget of $1.4 billion. Our project is focused on Parkland's Hospitalist department. Hospitalists are physicians who are licensed practitioners of hospital medicine and responsible for the management of day-to-day care of inpatients. A hospitalist can be scheduled as an admitter or a rounder. An admitter is tasked with handling the admission process for patients who are in the emergency department and waiting for a bed assignment, whereas a rounder is assigned to a group of patients who have already been assigned to beds. Parkland typically operates with 26 rounders who are labeled A-Z.

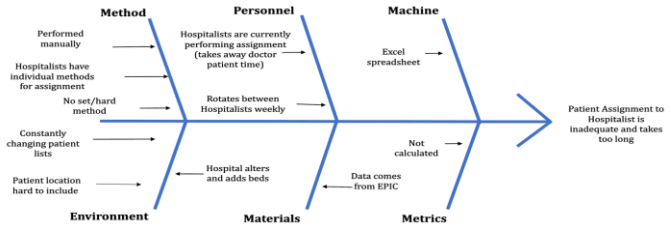
## Assigning Patients to Hospitalists

Each weekly shift, one hospitalist is assigned to be hospitalist A and is responsible for the daily assignment process, which is currently performed manually each morning at 7am. The first step of the process is to download the daily data from EPIC, an online medical database that Parkland uses. The next step of the process is to determine which hospitalists are working. If a hospitalist from yesterday is not working today, then all patients assigned to that hospitalist are either given to someone who is filling in or redistributed. Hospitalist A will then try to balance the number of patients between hospitalist's while taking into consideration unit preferences and patient severity. A typical morning will have 50+ patients who need to be assigned to hospitalist teams.



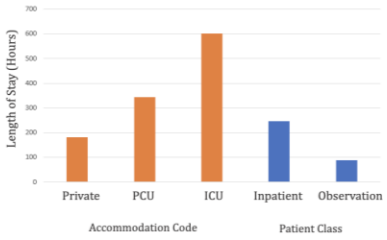

Loop through for all Hospitalist Teams

Parkland has 5 main concerns about their current process: 1. the manual nature of the process 2. the fairness of workload among hospitalists 3. hospitalists are unable to attend morning multi-disciplinary huddle for all patients 4. the travel time between patients 5. the second manual process that is completed on Wednesday for patient redistribution. The Wednesday redistribution consists of reassigning all existing patients to a new hospitalist team for shift change each week.




## Calculating Patient Severity Scores

To calculate a severity score for each patient, we determined factors that affected a patient's length of stay. Using statistical testing we found that a patient's accommodation code and patient class affected length of stay. These two factors along with three others given to us by Parkland were used to calculate a patient's severity score. To calculate a patient's severity score, all factors for that patient are multiplied together as detailed below.




| Severity Factor | Weight |
|---|---|
| Inpatient | 1 |
| Outpatient | 0.8 |
| Private | 1 |
| ICU | 1.5 |
| PCU | 1.33 |
| Patient Requires Isolation | 1.1 |
| Patient Does Not Require Isolation | 1 |
| Patient Has Already Been Seen | 1 |
| Patient Has Not Already Been Seen | 1.5 |
| Patient Requires Telemetry | 1.1 |
| Patient Does Not Require Telemetry | 1 |

Patient X = 2.25

## Optimizing Workload Balance

Using our calculated severity scores, we created an assignment optimization model that assigns patients to hospitalist teams while minimizing imbalance of workload and ensuring each patient assigned to a team is located on a unit within that team's unit preferences.

Parameters

$a\{P\}$ contains patient severity scores $\forall P$

$v\{H\}$ defines the previous cumulative severity scores $\forall H$

$b\{P\}$ contains the unit each patient is on $\forall P$

$j\{H, pref\}$ defines the units that hospitalists can work on $\forall H$

Decision Variables

$X\{P, H\}$ is 1 if patient $P$ is assigned to hospitalist $H$ and 0 otherwise

Highest cumulative severity score – lowest cumulative severity score — Objective — Minimize $Max - Min$

Every patient must be assigned a hospitalist — Subject to $\sum_{h \text{ in } H} X[p,h] = 1 \; \forall P$

Creates value of minimum cumulative severity score $\sum_{h \text{ in } H} a[p] * X[p,h] + v[h] \geq Min$

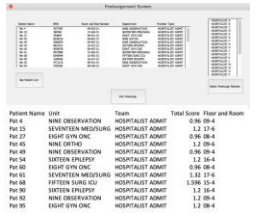
Creates value of maximum cumulative severity score $\sum_{h \text{ in } H} a[p] * X[p,h] + v[h] \leq Max$

If a patient is given to a hospitalist the hospitalist is given patients unit $X[p,h] \leq G[h, b[p]] \; \forall H, P$

Hospitalists can only receive patients residing in unit preferences $\sum_{u \text{ in } U} G[h,u] - \sum_{z \text{ in } pref} G[h, j[h,z]] \leq 0$

## Improving the Data Collection Process

We created a user-friendly excel Visual Basic tool that allows the user to navigate through multiple interface screens to pre assign patients, select criteria that can alter severity scores, and output a formatted excel file to be read in by our optimization solver. The first page brings the user to a welcome screen allowing them to import the data file downloaded from EPIC. This data is then automatically cleaned and standardized by the tool. The user is then brought to the second screen where the user can select if a hospitalist team is working today, if a hospitalist's patients need to be redistributed, or if someone is filling in for that hospitalist. The user then navigates through a screen allowing them to select which admit patients have been seen, which affects the severity score of a patient, and they can pre assign patients to hospitalists before exporting a new excel file with formatted data read in by a python script.



## Transferring the Optimization to Parkland

Using the excel file output from our VBA tool the user then runs a python script to read in the excel file, build the optimization model using Python Pyomo, and automatically output results to a .txt file that can be stored. The output .txt file displays the objective value, a proposed patient assignment list, and summary statistics used to measure the workload between all of the hospitalist teams.

```
Objective = 4.20

PATIENT HOSPITALIST
Pat 25 HOSPITALIST N  1.00
Pat 28 HOSPITALIST Q  1.00
Pat 32 HOSPITALIST B  1.00

Average Cumulative Severity Score =  12.29
```

| HOSPITALIST | CUMULATIVE SEVERITY SCORE | DEVIATION | OLD PATIENT COUNT | NEW PATIENT COUNT | # PATIENTS ADDED |
|---|---|---|---|---|---|
| HOSPITALIST A | 11.61 | 0.68 | 8 | 12.0 | 4.0 |
| HOSPITALIST B | 11.47 | 0.82 | 8 | 12.0 | 4.0 |
| HOSPITALIST C | 11.44 | 0.86 | 11 | 12.0 | 1.0 |
| HOSPITALIST D | 12.46 | 0.17 | 9 | 12.0 | 3.0 |
| HOSPITALIST E | 13.04 | 0.75 | 13 | 13.0 | 0.0 |
| HOSPITALIST F | 11.97 | 0.32 | 11 | 12.0 | 1.0 |

Using historical data, detailed below, we were able to show a 50% improvement in the workload balance, and have estimated a 70% improvement in the time required to perform the assignment process. If you assume the process takes 1 hour per day, and the Wednesday redistribution takes 1 hour every Wednesday, this is a savings of 292 hours of work per year.