Using Optimization to Improve Monthly Resident Shift Scheduling for C.S. Mott Emergency Department
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Problem Statement

Background: C.S. Mott Pediatric Emergency Department (ED) at University of Michigan Health Systems
- Level 1 Pediatric Trauma Center
- Staffed by residents from 5 programs
- About 25,000 visits per year

Importance of Schedule Quality:
Poor-quality schedules can have a negative impact on
- Workflow
- Training quality and burnout rates
- Patient access, care quality, safety, and satisfaction

Traditional Approach: Hand-made schedule built by Chief Resident or administrator, requiring around 20 hours per month

Benefits | Drawbacks
---|---
Intimate Knowledge | Time-Consuming
Administrative Consolidation | Cognitively Demanding

The Challenge: Scheduling residents in the ED involves an overwhelming number of governing rules and preferences the scheduler must abide and consider.

Rules:
- All shifts require a resident
- 10 hour rest rule (ACGME)
- Continuity Clinics / Conferences
- Varying start dates and time off-requests
- Senior only shifts

Objective: Solve for a schedule quickly that satisfies all the rules while improving measures of schedule quality.

Quality | Time

Solution Approach

Metrics:
- Total Shift Equity (TSE)
- Night Shift Equity (NSE)
- Bad-Sleep Patterns (BSP)
- Post-Continuity Clinic Shifts (PCC)

Decision Variable: Whether to assign a certain resident to a certain shift on a certain day

\[ x_{s, d} \in \{0, 1\}, \quad \forall r \in R, s \in S, d \in D \]

Constraint Example, Work-Rest Rule: Residents must get at least 10 hours off-duty between ending one shift and beginning another

\[ x_{s, d} + \sum_{(r', s') \in \text{within 10 h of } (s,d)} x_{r', s'} \leq 1, \quad \forall r \in R, s \in S, d \in D \]

Feasibility Optimization Problem:

- Quantifying objective weights \(w_i\) is difficult due to
  - Non-linearity
  - Subjectivity
  - Speed (< 2 sec an iteration)

\[
\begin{align*}
\text{Minimize} & \quad \sum_{i=1}^n w_i x_i \\
\text{subject to} & \quad x_{s, d} \in \{0, 1\} \\
& \quad lb_{BSE} \leq (TSE) \leq ub_{BSE} \\
& \quad lb_{BSP} \leq (NSC) \leq ub_{BSP} \\
& \quad lb_{PCC} \leq (PCC) \leq ub_{PCC} \\
\end{align*}
\]

Iterative Improvement: engaging the Chief Resident to review, revise and finalize the schedule

<table>
<thead>
<tr>
<th>Resident Name</th>
<th>Number of Shifts</th>
<th>Number of Night Shifts</th>
<th>Number of Post-CC Shifts</th>
<th>Number of Bad Sleep Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stumpos</td>
<td>8 (7,9)</td>
<td>2 (2,3)</td>
<td>0 (0,1)</td>
<td>0 (0,0)</td>
</tr>
<tr>
<td>Schwein</td>
<td>8 (7,10)</td>
<td>2 (2,3)</td>
<td>0 (0,1)</td>
<td>0 (0,0)</td>
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<tr>
<td>Grum</td>
<td>8 (7,9)</td>
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</tr>
</tbody>
</table>

Impact/Results

Implementation Results:
- Reduced time to create schedules
  - 20 hours per month → 1 hour per month
- Statistically significant improvement in 3 of 4 metrics

Effect on Bad Sleep Patterns:

Effect on Night Shift Equity:

Conclusions - With our optimization based decision support tool we are able to:
- Significantly reduce time to build monthly schedules
- Improve metrics for generated schedules

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