CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
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Using Optimization to Improve Monthly Resident Shift Scheduling for C.S. Mott Emergency Department

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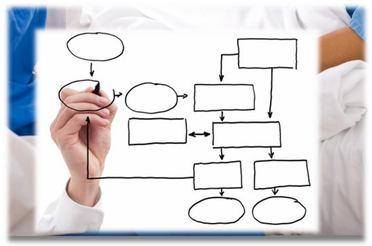
Problem Statement

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 ↓

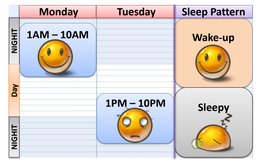
Solution Approach

Metrics:

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

Preferences? Weights? Trade-off?

Resident Name	Smith	Jones	Chen	Joe
Night Shifts / Total Shifts	0 / 7	1 / 7	1 / 7	5 / 7
Fairness				



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

$$x_{rsd} \in \{0,1\}, \qquad \forall\, r \in R, s \in S, d \in D$$

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

$$x_{rsd} + \sum_{\substack{(s',d') \in \\ \{within\ 10\ hrs\ of\ (s,d)\}}} x_{rs'd'} \leq 1, \qquad \forall\, r \in R, s \in S, d \in D$$

Feasibility ~~Optimization~~ Problem:

× Quantifying objective weights (w_i) is difficult due to
- Non-linearity
- Subjectivity

✓ Feasibility with metric bounds offers
- Flexibility
- Speed (< 2 sec an iteration)

$$\text{Min } \sout{w_1(TSE) + w_2(NSE) + w_3(BSP) + w_4(PCC)}$$
$$\text{s.t. } \text{"rules/requirements"}$$
$$x_{rsd} \in \{0,1\}$$
$$lb_{TSE} \leq (TSE) \leq ub_{TSE}$$
$$lb_{NSE} \leq (NSE) \leq ub_{NSE}$$
$$lb_{BSP} \leq (BSP) \leq ub_{BSP}$$
$$lb_{PCC} \leq (PCC) \leq ub_{PCC}$$

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

Resident Name	Number of Shifts	Number of Night Shifts	Number of Post-CC Shifts	Number of Bad Sleep Patterns
Stumpos	8 (7,9)	2 (2,3)	0 (0,1)	0 (0,0)
Schwein	8 (7,10)	2 (2,3)	0 (0,1)	0 (0,0)
Grum	8 (7,9)	2 (2,3)	1 (0,1)	0 (0,0)
⋮	⋮	⋮	⋮	⋮

Impact/Results

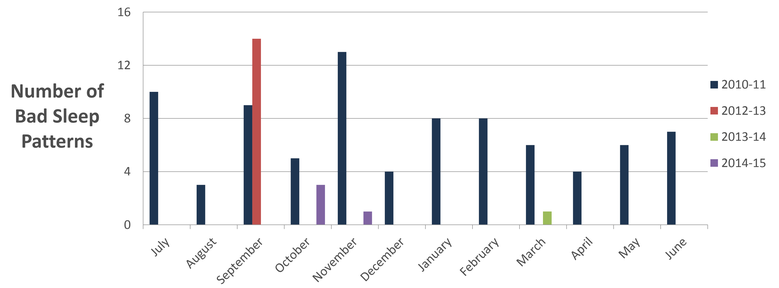
Implementation Results:

- Reduced time to create schedules

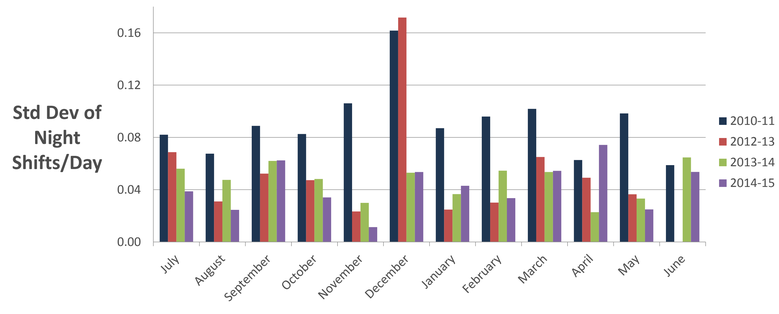
20 hours per month → 1 hour per month

- 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

Acknowledgements

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