Optimizing Resident Call Assignments

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Research Area Specialist
Center for Healthcare Engineering and Patient Safety
1. Background
2. Formulation
3. Implementation
4. Remarks
St. Joseph Mercy Hospital

Ypsilanti, MI
545 beds
150 residents

11,200+ surgical cases per year
2,100+ general surgery cases per year
General Surgery Residency
@ St. Joseph Mercy Hospital

5-year program | 5 residents per graduating class

Monthly rotations offer exposure to subspecialties

Residents work daily call and rounding teams
Call and rounding teams

Chief resident constructs monthly teams, in accordance with:

• Monthly rotation assignments
• Call and rounding team coverage needs
• Resident well-being guidelines
• Schedule preferences
## Monthly rotation assignments

### Core Rotations:
- **Purple**
- **Orange**
- **Red**
- **Green**
- **Blue**
- **Yellow**

### Additional Rotations:
- SICU
- SMMH
- SJLH
- Endoscopy
- Thoracic
- ED Nights
- Anesthesia
## Call team coverage needs

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<tr>
<th>CALLS</th>
<th>SUN</th>
<th>MON</th>
<th>TUE</th>
<th>WED</th>
<th>THU</th>
<th>FRI</th>
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# Rounding team coverage needs

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Resident well-being guidelines

1. Pre-scheduled vacations cannot be overridden
2. Certain residents have pre-assigned duties but cannot be assigned to additional tasks
3. Every resident must get 2 full weekends off
4. Residents cannot work partial weekends
5. Residents need adequate rest between tasks

6. Senior residents cannot be assigned more than one Friday or Saturday call

7. Residents cannot be assigned more than 2 calls in any 6 consecutive days
Schedule preferences

1. Try to distribute calls and rounds equitably

2. Try to assign a senior and junior from each of the Purple, Orange, Red, Green, and Blue/Yellow core rotations to each day’s rounding team

3. Try to avoid assigning PGY1s on the Purple team to calls Sunday-Tuesday

4. Try to avoid assigning PGY5s on the Orange team to calls Tuesday-Wednesday
Develop a decision support system to enable fast construction while simultaneously improving quality of call schedules.
Inputs and decision variables

\[ \begin{align*}
R & \quad \text{Set of residents} \\
& \quad \text{(w/ level & monthly rotation assignment)} \\
T & \quad \text{Set of tasks} \\
D & \quad \text{Set of dates in horizon}
\end{align*} \]

\[ x_{rtd} = \begin{cases} 
1: & \text{if assigning resident } r \text{ to task } t \text{ on date } d \\
0: & \text{otherwise}
\end{cases} \]
### Constraints

**Task coverage**
\[ l_c \leq \sum_{r \in R_c} \sum_{t \in T_c} \sum_{d \in D_c} x_{rtd} \leq u_c \quad \forall (R_c, T_c, D_c) \in C \]

**Resident needs**
\[ l_q \leq \sum_{t \in T_q} \sum_{d \in D_q} x_{rqt} \leq u_q \quad \forall (r_q, T_q, D_q) \in Q \]

**Spacing**
\[ x_{rsd} + x_{rst} \leq 1 \quad \forall r \in R, d \in D, d' \in D_s, (s_s, t_s, D_s) \in S \]

**Paired tasks**
\[ x_{rfj} - x_{rsje} = 0 \quad \forall r \in R, (f_j, d_j, s_j, e_j) \in J \]

**Pre-assignments**
\[ x_{rat} = 1 \quad \forall (R_a, T_a, D_a) \in A \]

**Prohibitions**
\[ x_{rpt} = 0 \quad \forall (R_p, T_p, D_p) \in P \]
Important to consider **numerous metrics**, but no obvious objective function

- Equitable assignment distribution
- Senior/junior core team representation on rounding teams
- **Purple** interns off-duty Sun-Tue
- **Orange** PGY5s off-duty Tue-Wed

**Options:**

1. Optimize **weighted sum** of metrics
2. Optimize metrics **hierarchically**
3. Something else?
Implementation process

1. Formulate

2. Encode (C++ w/ CPLEX 12.4)

3. Load (monthly inputs)

4. Solve (≤60 s)

5. Review
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<th>RESIDENT</th>
<th>TEAM</th>
<th>LEVEL</th>
<th>SENIOR</th>
<th>MID AM</th>
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<th>INTERN</th>
<th>ROUNDS</th>
<th>VACAY</th>
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## Calendar View

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Impact

To date, scheduled December ‘17 through June ‘18

**Time**

- Solve time: ≤ 60 s
- Review meeting: ≤ 1 hr

**Quality**

- Equitable assignment distribution
  Residents ± 1 assignment relative to cohort
- Senior/junior core team reps on rounds
  100% days w/ 1+ resident from each core team
- Purple interns off-duty Sun-Tue
  Granted every month since introduction
- Orange PGY5s off-duty Tue-Wed
  Granted every month since introduction

Experiential learning for student team
Lessons learned

Robust constraint design plus flexible input formats enable rapid rule integration

Match reports to existing tools
Future work

Streamline schedule revision process

New application area: PICU attending/fellow schedule coordination
Acknowledgements

Thanks to the chief residents for their collaboration and to the students who have helped build this tool.

Special thanks for the generous support from: 

[Logos of Saint Joseph Mercy Health System and Seth Bonder Foundation]
Questions and comments

Thank you!

William Pozehl  |  pozewil@med.umich.edu
Amy Cohn       |  amycohn@med.umich.edu
Medical training pathway

Undergrad Student → Medical Student → Resident → (Fellow) → Attending Physician

Resident

Post-medical school physician trainee
Patient care provider under supervision of attending physicians
Importance of residency schedules

...clinical and administrative workflow

...patient access, care quality, safety, and satisfaction

...training quality and burnout rates
Task Coverage

Coverage Constraints:

• Ensures the correct number of residents from a set of residents are assigned to cover a set of tasks over a set of dates
• Focused on staffing perspective to ensure tasks are covered

$$l_c \leq \sum_{r \in R_c} \sum_{t \in T_c} \sum_{d \in D_c} x_{rtd} \leq u_c \forall (R_c, T_c, D_c) \in C$$
Resident Requirements

Resident Requirement Constraints:
• Ensures the correct number tasks from a set of tasks assigned to a resident over a set of dates
• Focused on resident learning perspective to ensure a correct number of shifts are assigned to each resident
Task Spacing

Task Spacing Constraints:

1. Ensures two specified tasks cannot be assigned to a resident within the specified time frame.
2. Used to ensure residents are provided the required amount of rest between shifts.

Mathematically:

\[ x_{rsd} + x_{rtd'} \leq 1 \quad \forall \ r \in R, \ d \in D, \ d' \in D_S, \ (s_s, t_s, D_s) \in S \]
Paired Tasks

\[ x_{rfjdj} - x_{rsjej} = 0 \quad \forall r \in R, (f, d, s, e) \in J \]

Paired Tasks Constraints:
- Ensures two specified tasks must be completed together on the specified dates
- Primarily used to ensure full weekends off are allotted
Pre-assignments & Prohibitions

Pre-assignments
\[ x_{r_{a}t_{a}d_{a}} = 1 \quad \forall \ (R_{a}, T_{a}, D_{a}) \in A \]

Prohibitions
\[ x_{r_{a}t_{a}d_{a}} = 0 \quad \forall \ (R_{p}, T_{p}, D_{p}) \in P \]

Pre-assignment and Prohibition Constraints:
- Used to enforce a mandatory or prohibited task for a resident on a specified date
Deployment

Implementation Team

• (2) Industrial Engineering undergraduates
• (1) Computer Science undergraduate

...under supervision of Prof. Cohn
# Task report

<table>
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