Optimization-Based Tools For Residency Scheduling

Amy Cohn, Young-Chae Hong, Micah Long, Mindy Alberty
University of Michigan
INFORMS Phoenix 2012

Acknowledgements

- Ongoing collaborative work with many key players and talented contributors
  - Chief Residents:
    - Dr. Dan O'Connell
    - Dr. Brian Jordan
  - Former students:
    - Xun Xu
    - Kathy Lu
    - Marcial Lapp
    - Siyuan Sun
    - Jinshuai Guo
    - Yiwen Jiang
    - Tara Lynn O'Gara

What is medical residency?

- Transition period between medical school and fully independent/unsupervised practice
  - Four years of med school
  - First year of residency – "Intern"
  - Two or more years of residency
  - Possibly one or two additional years as "Chief Resident"
  - Possibly more years as a "Fellow"
- During all of this time, providing patient care (albeit with the oversight of a more senior "attending" physician –supervision decreases over time)

What is medical residency?

- A key issue: Dual role of residency
  - Learning experience: Residency (and Fellowship) are parts of the medical education training process
  - Patient care: Residents/Fellows provide a significant amount of the patient care in teaching hospitals and the associated clinical system
- A typical resident might engage in all of the following activities:
  - "Continuity clinics"
  - Shifts on service
  - Seminars, formal educational activities
  - Research

Inherent Time Conflicts

- How to schedule residents' time
  - Need adequate patient coverage with a limited pool of residents
  - Need adequate training opportunities
  - Need adequate rest – fatigue increases risk of error
  - Need to address resident satisfaction, personal life
- Not just quantity of hours but pattern
  - Continuity of care
  - Sleep issues (especially associated with overnight shifts)
  - Opportunities for different medical experiences

Residency Scheduling

- Two types of scheduling
  - Block scheduling
  - Shift scheduling
- Shift scheduling:
  - Given a time horizon
  - Given a set of shifts per day
  - Given a set of residents (heterogeneous set)
    - Residency program
    - Seniority
  - Assign residents to staff these shifts

Hard Constraints

- The following are rules that “must” be satisfied
- Resident perspective:
  - At least 10 hours off after every shift
  - Respect pre-scheduled vacation time
  - Min and max number of shifts per month
  - Start and end dates (moving from one service to another – interns shift earlier to overlap with the more experienced senior residents)
  - Continuity clinics

Hard Constraints

- The following are rules that “must” be satisfied
- Shift perspective:
  - Minimum and maximum number of residents per shift
  - Resident characteristics (e.g. some shifts must have a senior resident)
  - Overlapping shift pairs – one of the two must come from the Peds program

Metrics

- There are some things that are not hard requirements, but we still care about
- Resident perspective:
  - How many night/weekend shifts worked
  - Post-clinic shifts
  - Day-off requests
  - Equity across residents
- Shift perspective:
  - Optional shifts covered
  - Continuity of care/Continuity of training

Why should we care?

- Started off working in this area as a favor
- Continued working initially because of the mathematics – application was interesting but impact seemed limited
  - More time for Chief Resident
  - Residents happier about getting schedule preferences

Why should we care?

- Number of residents is set and fixed externally (i.e. a program can't independently increase the number of residents to increase staffing)
- ACGME limits the amount of duty hours, patterns and frequency of time off, etc.
  - Have made some major increase to limitations in the past
  - Current talk about further tightening of restrictions
- This means there is not a lot of slack in the system, and it's likely to get worse
- ACGME tightening -> Manual process shifts from (a) hard work to get a good schedule to (b) hard work to get a not very good schedule to (c) hard work and still don't have a schedule!

Why should we care?

- Now, I'm seeing impact in lots of different ways
  - Continuity clinics
  - Sleep issues – applicable to attendings/faculty as well as residents
  - Continuity of care (e.g. resident/attending pairing)
  - Matching schedule with (stochastic) rare opportunities

7

Why is this hard?

	6		1		4		5	
		8	3		5	6		
2								1
8			4		7			6
		6				3		
7			9		1			4
5								2
		7	2		6	9		
	4		5		8		7	

- The more squares you fill in, the fewer choices you have left for what is valid
- Once you make a mistake, you might not know it for a long time
- Once you realize something is wrong, it can be very hard to back track and correct

Current State

- Schedules typically built by Chief Residents
- Limited decision support
- No formal training
- Hard to satisfy all rules
- Unlikely to make everyone happy

Our Approach

- This is exactly what we do!
  - Combinatorial optimization
  - Lots of interactions
  - Need a systematic approach to consider all parts concurrently

Our Approach

- Constraints are fairly straightforward to model
- $x_{rsd} = 1$ if resident r is assigned to shift s for day d, else 0
- What is our objective function?

Our Approach

- Hard to quantify
  - Many criteria
  - Not clear how to weight them
  - Run time of feasibility vs. optimality can vary significantly
- Optimality is neither defined nor needed
- Chiefs can identify what is good or bad in a schedule by inspection
- Solve via metrics and an iterative process

Where to go next

- Make more operational / sustainable / affordable / more general / independent
- Pareto dominant solutions
- Reducing variation from one iteration to another
- Robustness