Optimization-Based Tools For Residency Scheduling

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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?

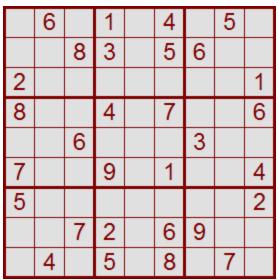
- Number of residents is set and fixed externally (i.e. a program can't independently increase the number of residents to increase staffing)
- ACGME limits the amount of duty hours, patterns and frequency of time off, etc.
 - Have made some major increase to limitations in the past
 - Current talk about 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

Why is this hard?

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- 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

