Operating Room Scheduling

Making Hospitals Run Smoothly

15.071x – The Analytics Edge

Operating Room Schedules

- Hospitals have a limited number of ORs.

- Operating room managers must determine a weekly schedule assigning ORs to different departments in the hospital.

Difficulties

- Creating an acceptable schedule is a highly political process within the hospital.
- Surgeons are frequently paid on a fee-for-service basis, so changing allocated OR hours directly affects their income.
- The operating room manager's proposed schedule must strike a delicate balance between all the surgical departments in the hospital.

Logistical Issues

- Operating rooms are staffed in 8 hour blocks.
- Each department sets their own target number of allocation hours, which may not be integer.
- Departments may have daily and weekly requirements:
  - Ex) Gynecology needs at least 1 OR per day
  - Ex) Ophthalmology needs at least 2 ORs per week
  - Ex) The oral surgeon is only present on Tuesdays and Thursdays.

Case study: Mount Sinai Hospital

- Has 10 ORs which are staffed Monday – Friday
  - 10 ORs × 5 days × 8 hours/day = 400 hours to assign
- Must divide these 400 hours between 5 departments:

Department	Weekly Target Allocation Hours
Ophthalmology	39.4
Gynecology	117.4
Oral Surgery	19.9
Otolaryngology	26.3
General Surgery	189.0

Problem Data

- Number of surgery teams from each department available each day:

	M	T	W	R	F
Ophthalmology	2	2	2	2	2
Gynecology	3	3	3	3	3
Oral Surgery	0	1	0	1	0
Otolaryngology	1	1	1	1	1
General Surgery	6	6	6	6	6

- Maximum number of ORs required by each department each day:

	M	T	W	R	F
Ophthalmology	2	2	2	2	2
Gynecology	3	3	3	3	3
Oral Surgery	1	1	1	1	1
Otolaryngology	1	1	1	1	1
General Surgery	6	6	6	6	6

Additional Problem Data

- Weekly requirement on number of ORs each department requires:

	Minimum	Maximum
Ophthalmology	3	6
Gynecology	12	18
Oral Surgery	2	3
Otolaryngology	2	4
General Surgery	18	25

The Traditional Way

- Before the integer optimization method was implemented at Mount Sinai in 1999, the OR manager used graph paper and a large eraser to try to assign the OR blocks.
- Any changes were incorporated by trial and error.
- Draft schedule was circulated to all surgical groups.
- Incorporating feedback from one department usually meant altering another group's schedule, leading to many iterations of this process.

Optimization Problem

- Decisions
  - How many ORs to assign each department on each day.
  - Integer decision variables x_{jk} represent the number of operating rooms department j is allocated on day k.

Objective

- Maximize % of target allocation hours that each department is actually allocated.

- If target allocation hours are t_j for department j, then we want to maximize the sum of $(8 \times x_{jk}) \div t_j$ over all departments and days of the week.

Objective

- Maximize % of target allocation hours that each department is actually allocated.

- If target allocation hours are t_j for department j, then we want to maximize the sum of $(8 \times x_{jk}) \div t_j$ over all departments and days of the week.
  - Ex) If otolaryngology has a target of 37.3 hours per week and we allocate them 4 ORs then their % of target allocation hours = $(8 \times 4) \div 37.3 = 85.8\%$

Constraints

- At most 10 ORs are assigned every day
- The number of ORs allocated to a department on a given day cannot exceed the number of surgery teams that department has available that day
- Meet department daily minimums and maximums
- Meet department weekly minimums and maximums

Ophthalmology	OP
Gynecology	GY
Oral Surgery	OS
Otolaryngology	OT
General Surgery	GS

Constraints

- $x_{OP,M} + x_{GY,M} + x_{OS,M} + x_{OT,M} + x_{GS,M} \leq 10$
- The number of ORs allocated to a department on a given day cannot exceed the number of surgery teams that department has available that day
- Meet department daily minimums and maximums
- Meet department weekly minimums and maximums

Ophthalmology	OP
Gynecology	GY
Oral Surgery	OS
Otolaryngology	OT
General Surgery	GS

Constraints

- $x_{OP,\,M} + x_{GY,\,M} + x_{OS,\,M} + x_{OT,\,M} + x_{GS,\,M} \leq 10$
- $0 \leq x_{GY,\,F} \leq 3$
- $0 \leq x_{OS,\,W} \leq 0$
- Meet department daily minimums and maximums
- Meet department weekly minimums and maximums

Ophthalmology	OP
Gynecology	GY
Oral Surgery	OS
Otolaryngology	OT
General Surgery	GS

Constraints

- $x_{OP,\,M} + x_{GY,\,M} + x_{OS,\,M} + x_{OT,\,M} + x_{GS,\,M} \leq 10$
- $0 \leq x_{OS,\,W} \leq 3$
- $0 \leq x_{GY,\,F} \leq 0$
- $0 \leq x_{GS,\,T} \leq 6$
- Meet department weekly minimums and maximums

Ophthalmology	OP
Gynecology	GY
Oral Surgery	OS
Otolaryngology	OT
General Surgery	GS

Constraints

- $x_{OP,\,M} + x_{GY,\,M} + x_{OS,\,M} + x_{OT,\,M} + x_{GS,\,M} \leq 10$
- $0 \leq x_{OS,\,W} \leq 3$
- $0 \leq x_{GY,\,F} \leq 0$
- $0 \leq x_{GS,\,T} \leq 8$
- $3 \leq x_{OP,\,M} + x_{OP,\,T} + x_{OP,\,W} + x_{OP,\,R} + x_{OP,\,F} \leq 6$

Ophthalmology	OP
Gynecology	GY
Oral Surgery	OS
Otolaryngology	OT
General Surgery	GS