HEALTHCARE SYSTEMS PROCESS IMPROVEMENT CONFERENCE 2018

Sponsored by: SOCIETY FOR HEALTH SYSTEMS
LEADING HEALTHCARE IMPROVEMENT

Applying Optimization Techniques to Surgical Call Scheduling

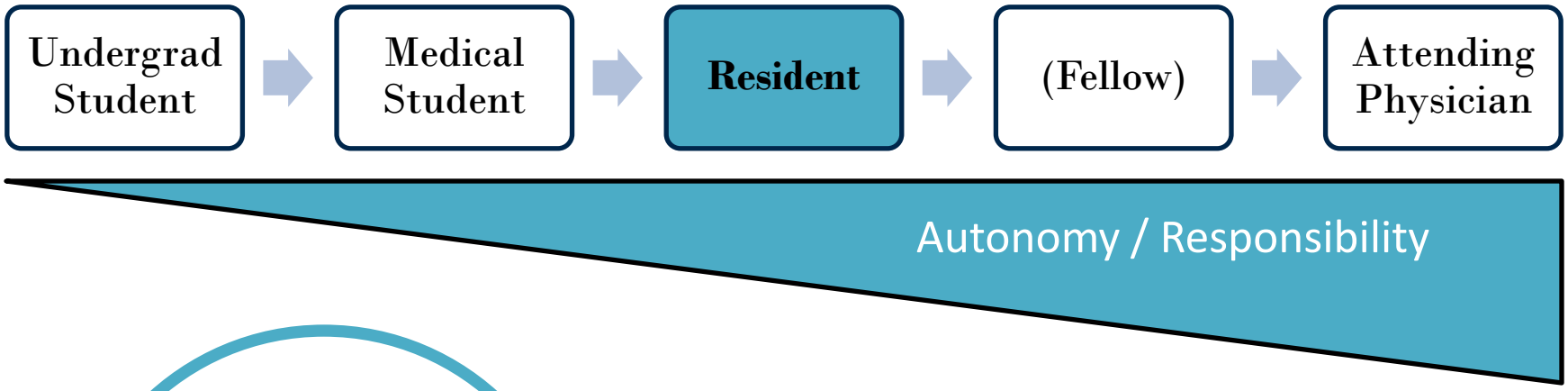
William Pozehl

Research Area Specialist

Presentation outline

1. Residency
2. Model
3. Implementation
4. Conclusions

Medical training pathway

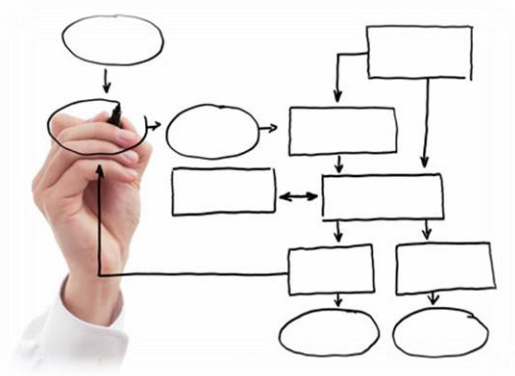


Resident

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

St. Joseph Mercy Hospital

Ypsilanti, MI

545 beds

150 residents

32,300+ visits per year

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

Extensive training with trauma, peripheral vascular, and cardiac patients

Monthly rotations offer exposure to subspecialty disciplines (e.g., anesthesia, emergency medicine, endoscopy, ICU, pediatrics, etc.)

Residents work **daily call** and **rounding** teams

Call and rounding teams

Chief resident tasked with building these teams

Teams built in accordance with:

- Monthly rotation assignments
- Call team needs
- Rounding team 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 needs

CALLS	SUN	MON	TUE	WED	THU	FRI	SAT
Chief	1 (PGY4/5)	1 (PGY4/5)	1 (PGY4/5)	1 (PGY4/5)	1 (PGY4/5)	1 (PGY4/5)	1 (PGY4/5)
Mid-level AM	1 (PGY2/3)	–	–	–	–	–	1 (PGY2/3)
Mid-level PM	1 (PGY2/3)	1 (PGY2/3)	1 (PGY2/3)	1 (PGY2/3)	1 (PGY2/3)	1 (PGY2/3)	1 (PGY2/3)
Intern	1 (PGY1)	1 (PGY1)	1 (PGY1)	1 (PGY1)	1 (PGY1)	1 (PGY1)	1 (PGY1)

Rounding team needs

ROUNDS	SUN	MON	TUE	WED	THU	FRI	SAT
Senior	5 (PGY3/4/5)	–	–	–	–	–	5 (PGY3/4/5)
Junior	5 (PGY1/2/3)	–	–	–	–	–	5 (PGY1/2/3)
Total	10+ (PGY1/2/3/4/5)	–	–	–	–	–	10+ (PGY1/2/3/4/5)

Resident well-being guidelines

1. Residents may not be assigned tasks that conflict with pre-scheduled vacations
2. Chief residents (PGY4/5) may not be given call on more than one Friday or Saturday
3. Every resident must get 2 full weekends off
4. If assigning a resident to work on Saturday, they must also work on Sunday (and vice versa)

Resident well-being guidelines, cont.

5. Residents need adequate rest between tasks
6. Residents may not be assigned more than 2 calls in any 6 consecutive days
7. Certain residents have pre-assigned duties but are otherwise unavailable

Schedule preferences

1. Try to distribute call and rounding assignments 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

Research objective

Develop a decision support system to enable
fast construction *while simultaneously*
improving quality *of call schedules*

Time ↓ **Quality** ↑

Presentation outline

1. Residency
2. **Model**
3. Implementation
4. Conclusions

Inputs and decision variables

R	–	Set of residents (w/ level & monthly rotation assignment)
T	–	Set of tasks
D	–	Set of dates in horizon

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

Constraints

Task Coverage	l_c	$\leq$	$\sum_{r \in R_c} \sum_{t \in T_c} \sum_{d \in D_c} x_{rtd}$	$\leq u_c$	$\forall (R_c, T_c, D_c) \in C$
Resident Needs	l_q	$\leq$	$\sum_{t \in T_q} \sum_{d \in D_q} x_{r_q td}$	$\leq u_q$	$\forall (r_q, T_q, D_q) \in Q$
Spacing			$x_{rs_s d} + x_{rt_s d'}$	≤ 1	$\forall r \in R, d \in D,$ $d' \in D_s,$ $(s_s, t_s, D_s) \in S$
Paired Tasks			$x_{rf_j d_j} - x_{rs_j e_j}$	$= 0$	$\forall r \in R, (f_j, d_j, s_j, e_j) \in J$
Pre-assignments			$x_{r_a t_a d_a}$	$= 1$	$\forall (R_a, T_a, D_a) \in A$
Prohibitions			$x_{r_p t_p d_p}$	$= 0$	$\forall (R_p, T_p, D_p) \in P$

Objective?

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

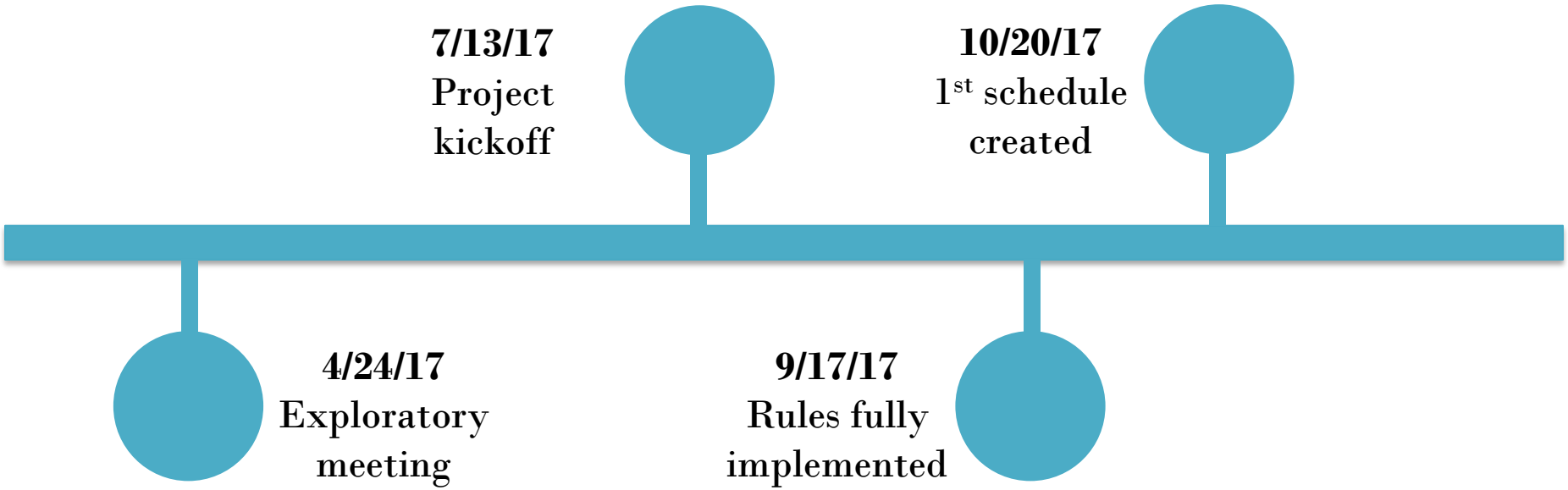
Options:

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

Presentation outline

1. Residency
2. Model
3. **Implementation**
4. Conclusions

Deployment

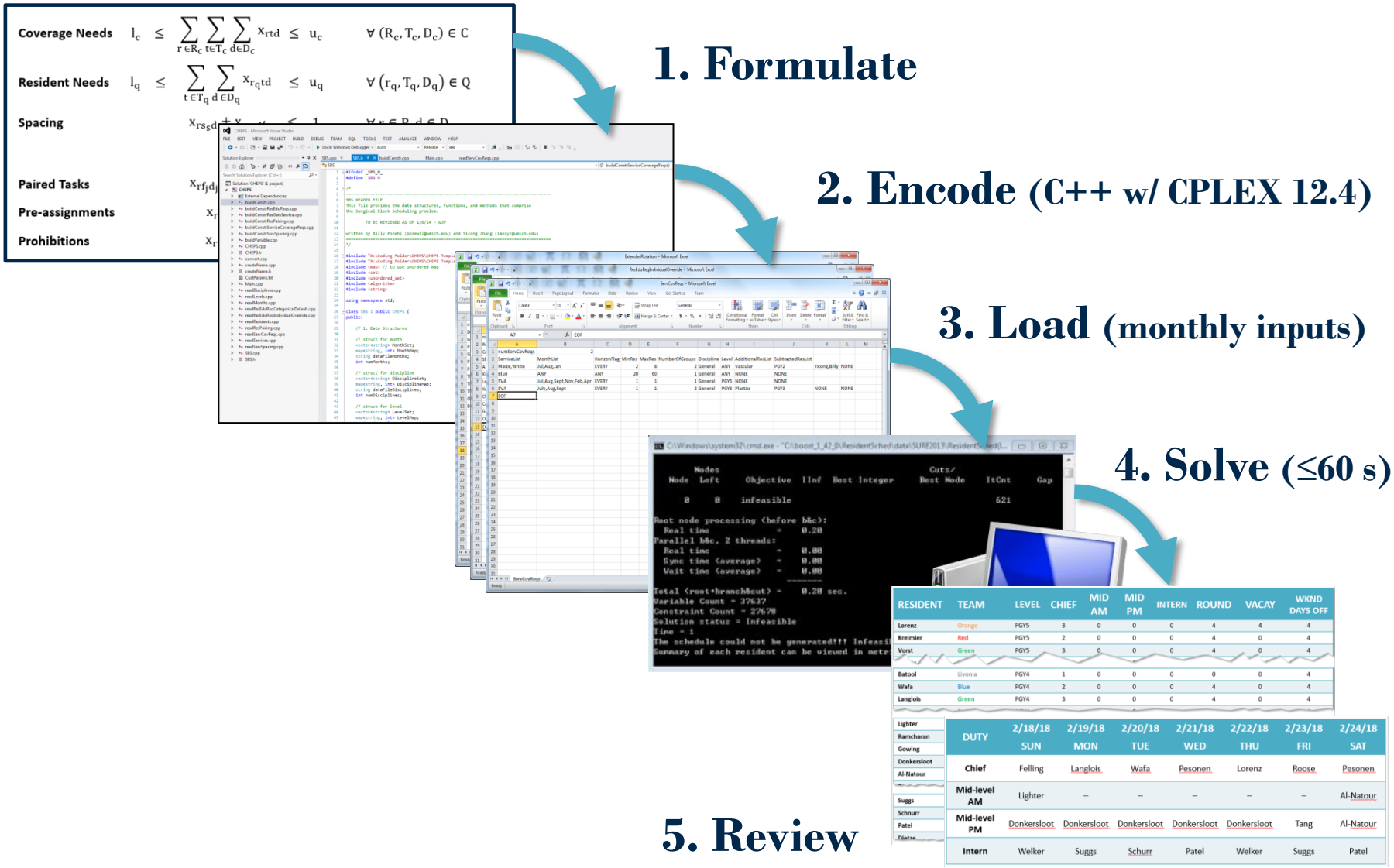


Implementation Team

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

…under supervision of Prof. Cohn

Implementation process



Summary report

RESIDENT	TEAM	LEVEL	CHIEF	MID AM	MID PM	INTERN	ROUNDS	VACAY	WKND DAYS OFF
Lorenz	Orange	PGY5	3	0	0	0	4	4	4
Kreimier	Red	PGY5	2	0	0	0	4	0	4
Vorst	Green	PGY5	3	0	0	0	4	0	4
Batool	Livonia	PGY4	1	0	0	0	0	0	4
Wafa	Blue	PGY4	2	0	0	0	4	0	4
Langlois	Green	PGY4	3	0	0	0	4	0	4
Lighter	Yellow	PGY3	0	1	1	0	4	7	4
Ramcharan	SICU	PGY3	0	1	1	0	2	0	0
Gowing	SICU	PGY3	0	1	1	0	2	0	0
Donkersloot	ED Nights	PGY3	0	0	20	0	0	0	0
Al-Natour	Red	PGY2	0	2	2	0	4	7	4
Suggs	Blue	PGY1	0	0	0	5	4	7	4
Schnurr	Purple	PGY1	0	0	0	6	4	0	4
Patel	Purple	PGY1	0	0	0	5	4	0	4
Dietze	Anesthesia	PGY1	0	0	0	6	6	7	2

Task report

DUTY	2/18/18 SUN	2/19/18 MON	2/20/18 TUE	2/21/18 WED	2/22/18 THU	2/23/18 FRI	2/24/18 SAT
Chief	Felling	Langlois	Wafa	Pesonen	Lorenz	Roose	Pesonen
Mid-level AM	Lighter	–	–	–	–	–	Al-Natour
Mid-level PM	Donkersloot	Donkersloot	Donkersloot	Donkersloot	Donkersloot	Tang	Al-Natour
Intern	Welker	Suggs	Schurr	Patel	Welker	Suggs	Patel

Resident report

WELKER | GREEN TEAM | PGY1			
SAT	2/17/18	Rounding	
SUN	2/18/18	Intern	Rounding
MON	2/19/18		
TUE	2/20/18		
WED	2/21/18		
THU	2/22/18	Intern	
FRI	2/23/18		
SAT	2/24/18	Wknd Day Off	
SUN	2/25/18	Wknd Day Off	

Presentation outline

1. Residency
2. Model
3. Implementation
4. **Conclusions**

Impact

To date, scheduled December '17 through March '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 + flexible input formats → rapid rule integration

Match reports to existing tools

"Accept the unexpected" – Aaron Kanne

Future work

Streamline process for revisions

“Predictively” identify problems

Implement additional rules/metrics based on collaborator feedback

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:

SAINT JOSEPH MERCY HEALTH SYSTEM
A Member of Trinity Health

Seth Bonder Foundation

Questions and comments

CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

Thank you!

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

Task Coverage

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

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

Resident Requirements

Resident Requirement

$$l_q \leq \sum_{\mathrm{t} \in T_q} \sum_{\mathrm{d} \in D_q} x_{r_q t d} \leq \mathrm{u_q} \quad \forall \left(\mathrm{r_q}, \mathrm{T_q}, \mathrm{D_q}\right) \in Q$$

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

Spacing $$x_{rs_s d} + x_{rt_s d'} \leq 1 \qquad \forall\, r \in R, d \in D, d' \in D_s,$$

$$(s_s, t_s, D_s) \in S$$

Task Spacing Constraints:

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

Paired Tasks

Paired Tasks

$$x_{rf_jd_j} - x_{rs_je_j} = 0 \qquad \forall\, r \in R, \left(f_j, d_j, s_j, e_j\right) \in J$$

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 $\mathrm{x}_{\mathrm{r_a t_a d_a}} = 1 \quad \forall\, (R_a, T_a, D_a) \in A$

Prohibitions $\mathrm{x}_{\mathrm{r_a t_a d_a}} = 0 \quad \forall\, \left(R_p, T_p, D_p\right) \in P$

Pre-assignment and Prohibition Constraints:

- Used to enforce a mandatory or prohibited task for a resident on a specified date