CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

Night Team Scheduling for Pediatric Inpatient Residents

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Problem Statement

The pediatric rotation at Michigan Medicine requires residents to work certain night shifts every month. These “Night Team” residents cover the inpatient units (General, PICU, NICU, etc.) from 7pm to 7am on nights they are assigned.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				Apr 27 Interns: Seniors:	Apr 28 Interns: Seniors:	Apr 29 Interns: Seniors:
Apr 30 Interns: Seniors:	May 1 Interns: Seniors:	May 2 Interns: Seniors:	May 3 Interns: Seniors:	May 4 Interns: Seniors:	May 5 Interns: Seniors:	May 6 Interns: Seniors:
May 7 Interns: Seniors:	May 8 Interns: Seniors:	May 9 Interns: Seniors:	May 10 Interns: Seniors:	May 11 Interns: Seniors:	May 12 Interns: Seniors:	May 13 Interns: Seniors:
May 14 Interns: Seniors:	May 15 Interns: Seniors:	May 16 Interns: Seniors:	May 17 Interns: Seniors:	May 18 Interns: Seniors:	May 19 Interns: Seniors:	May 20 Interns: Seniors:
May 21 Interns: Seniors:	May 22 Interns: Seniors:	May 23 Interns: Seniors:	May 24 Interns: Seniors:	May 25 Interns: Seniors:	May 26 Interns: Seniors:	May 26 Interns: Seniors:
May 28 Interns: Seniors:	May 29 Interns: Seniors:	May 30 Interns: Seniors:	May 31 Interns: Seniors:			

Traditionally, chief residents construct the pediatric “Night Team” schedule by hand, a process that is resource-intensive yet often fails to satisfy the individual and collective needs of stakeholders.

Research Objective:

Develop a decision support system to enable fast construction of high-quality pediatric ”Night Team” schedules while improving measures of quality

Class	Name	Program	Start Date	End Date	LB Shifts	UB Shifts
Intern 1	Rogers	PEDS	April 27	May 11	7	10
Intern 2	Learis	PEDS	April 27	May 11	7	10
Intern 3	Pozehl	EM	May 1	May 15	7	10
Intern 4	Salka	PEDS	May 12	May 26	7	10
Intern 5	Gene	PEDS	May 12	May 25	6	10
Intern 6	Jamour	PEDS	May 12	May 26	7	10
Intern 7	Mize	EM	May 16	May 31	7	10
Senior 1	Cohn	PEDS	May 2	May 15	10	11
Senior 2	Moss	PEDS	May 1	May 14	10	11
Senior 3	Pandit	PEDS	May 1	May 15	10	11
Senior 4	Hirth	MED-PEDS	May 16	May 31	10	11
Senior 5	Abbas	PEDS	May 16	May 31	10	11
Senior 6	Ilyas	PEDS	May 16	May 31	10	11

Model

Objective Function

$$\min \sum_{r\in R}\sum_{d\in D}(w_2 f_{rd} + w_6 n_{rd}) + \sum_{r\in R} w_r \delta_r$$

Activity Limits	$\sum_{a\in A} x_{rad} = 1$	$\forall r \in R, d \in D$	Every resident is assigned to one activity per day
Coverage Requirements	$\sum_{r\in\{\text{interns}\}} x_{r(\text{nt})d} = a_i$	$\forall d \in D$	Required number of interns each day
	$\sum_{r\in\{\text{seniors}\}} x_{r(\text{nt})d} = a_s$	$\forall d \in D$	Required number of seniors each day
Minimum Work Sequences	$x_{r(\text{nt})0} \le x_{r(\text{nt})1}$	$\forall r \in R$	Every work sequence must be at least 2 nights in a row
	$x_{r(\text{nt})d} \le x_{r(\text{nt})(d-1)} + x_{r(\text{nt})(d+1)}$	$\forall r \in R,$ $d \in \{1,\dots,\lvert D\rvert - 2\}$	
	$x_{r(\text{nt})(\lvert D\rvert-1)} \le x_{r(\text{nt})(\lvert D\rvert-2)}$	$\forall r \in R$	
Maximum Work Sequences	$\sum_{d=d'}^{d'+M^{(\text{nt})}} x_{r(\text{nt})d} \le M^{(\text{nt})}$	$\forall r \in R,$ $d' \in \{1,\dots,$ $\lvert D\rvert - M^{(\text{nt})} - 2\}$	Every work sequence must be at most 6 nights in a row
Emergency Medicine Conferences	$\sum_{w\in W} y_{rw} \ge 1$	$\forall r \in \{\text{EM}\}$	EM residents must be able to attend at least one conference
	$y_{rw} \le x_{r(\text{do})(\text{Tue}_w)}$	$\forall r \in \{\text{EM}\}, w \in W$	Conference requires Tuesday off
	$y_{rw} \le x_{r(\text{do})(\text{Wed}_w)}$	$\forall r \in \{\text{EM}\}, w \in W$	Conference requires Wednesday off
Preferred Duration of Work Sequences	$f_{r(0)} + m^{(\text{nt})} - 1 \ge$ $x_{r(\text{nt})(0)} + x_{r(\text{nt})(1)} - x_{r(\text{nt})(2)}$	$\forall r \in R$	Ideally, work sequences range between 3 and 5 nights in a row
	$f_{rd} + m^{(\text{nt})} - 1 \ge$ $-x_{r(\text{nt})(d-1)} + x_{r(\text{nt})d}$ $-x_{r(\text{nt})(d+1)} + x_{r(\text{nt})(d+2)}$	$\forall r \in R,$ $d \in \{1,\dots,$ $\lvert D\rvert - m^{(\text{nt})} - 1\}$	
	$f_{r(\lvert D\rvert-2)} + m^{(\text{nt})} - 1 \ge$ $-x_{r(\text{nt})(\lvert D\rvert-3)} + x_{r(\text{nt})(\lvert D\rvert-2)}$ $-x_{r(\text{nt})(\lvert D\rvert-1)}$	$\forall r \in R$	
	$n_{rd} + M^{\text{nt}} - 1 \ge \sum_{d'=d}^{d+M^{\text{nt}}-1} x_{r(\text{nt})d'}$	$\forall r \in R,$ $d \in \{0,\dots,$ $\lvert D\rvert - m^{(\text{nt})} - 1\}$	
Preferred Shift Equality	$\delta_r \ge \bar{x} - \sum_{d\in D} x_{r(\text{nt})d}$	$\forall r \in R$	Ideally, residents should have equal numbers of shifts
	$\delta_r \ge \sum_{d\in D} x_{r(nt)d} - \bar{x}$	$\forall r \in R$	
Variable Restrictions	$x_{rd}\epsilon\{0,1\}$ $n_{rd}\epsilon\{0,1\}$ $f_{rd}\epsilon\{0,1\}$ $y_{rw}\epsilon\{0,1\}$ $\delta_r \ge 0$		

Impact/Results

Stakeholders reported improved satisfaction for:

- Limiting number of consecutive 2- and 6-day work sequences
- Satisfying vacation requests
- Enabling Emergency Medicine conference participation
- Ensuring schedule fairness

Month	# of 2-day Work Sequences	# of 6 Day Work Sequences	Requests Made	Requests Satisfied
January	0	0	1	100%
February	0	2	7	100%
March	0	0	3	100%
April	5	0	11	100%
May	4	0	9	100%
June	2	0	10	100%
July	5	0	16	100%
August	5	0	8	100%
September	6	1	14	85.7%
October	0	0	13	76.9%
November	4	0	6	100%

Future Work

Encode the tool in C++ using CPLEX to supplement ease of use

↑ Ease of Use

Inquire residents on additional areas of improvement in schedule

↑ Satisfaction

Expand the model to determine which dates are best to have 3 seniors + 0 interns vs 2 seniors + 2 interns

↑ Quality

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