1 Introduction

Staff scheduling in healthcare continues to be a vexing problem that consumes valuable managerial resources and whose complexity can impact the quality of care delivered and the job satisfaction of its highly skilled labor force. []

Wide range of staff scheduling problems whose details depend on the specific healthcare delivery subsystem we are talking about. Examples: recovery room nurses, floor nurses, lab technicians, pharmacists and pharmacy technicians, surgical techs, ED nurses and techs, transporters.

Introduce motivation for tactical tour scheduling problems via real projects

For many systems, the kernel of the problem is a tour scheduling problem in which staffing levels needed vary both by time of day and day of week.

2 Tour scheduling problems

2.1 Scheduling environment

Features of tour scheduling problems including notions of planning cycle, periods, required staffing levels, shifts, tours, tour types, intra-tour start time flexibility,

2.2 Problem size explosion

2.3 Implicit modeling of tours

3 Related Work

Review one week implicit tour scheduling models including my AOR 2004 paper.

Recent multi-week implicit tour scheduling paper

4 Definitions and notation

Let W be the number of weeks in the planning cycle and P be the number of time periods per day. Typical values might be $W = 4$ and $P = 24$ to model a problem where staffing requirements are specified hourly and shifts can only start on the hour. The total number of periods in the planning cycle is den

$$\begin{aligned}
n_W &= \text{number of weeks in the planning cycle} \\
n_P &= \text{number of periods per day} \\
n_C &= 7 n_W n_P \text{ number of periods in planning cycle}
\end{aligned}$$

Define a number of sets of indices.

$$\begin{aligned}
P &= \{1, 2, \ldots n_P\} \\
D &= \{1, 2, \ldots 7\} \\
W &= \{1, 2, \ldots n_W\}
\end{aligned}$$

So, each period in the planning cycle is defined by a tuple $i, d, w \in B$ where $B = P \times D \times W$.

To smooth the postpartum occupancy across days of the week, we introduce two, non-negative, dummy variables, M^U and M^L. These are used to bound the mean occupancy across the week from above and below – see Equation (2). Then we minimize the difference between the bounds.

Model: OB-SMOOTH
Minimize

$$M^U - M^L \tag{1}$$

Subject to

$$0 \leq M^L \leq \mu^4_{i,j} \leq M^U \quad (i = 1,2,\ldots P,\ j = 1,2,\ldots 7) \tag{2}$$

$$L^a_{i,j} \leq \Lambda^a_{i,j} \leq U^a_{i,j} \quad (a = 5,6, i = 1,2,\ldots P,\ j = 1,2,\ldots 7) \tag{3}$$

$$L^a_{\cdot,j} \leq \sum_{i=1}^{P} \Lambda^a_{i,j} \leq U^a_{\cdot,j} \quad (a = 5,6,\ j = 1,2,\ldots 7) \tag{4}$$

$$L^a \leq \sum_{i=1}^{P} \sum_{j=1}^{7} \Lambda^a_{i,j} \leq U^a \quad (a = 5,6) \tag{5}$$

$$\text{Equations (\textbf{??})-(\textbf{??}) for arrival rates} \tag{6}$$

$$\text{Equation (\textbf{??}) for discharge rates} \tag{7}$$

$$\text{Equation (12) for conservation of flow} \tag{8}$$

$$\text{Equation (\textbf{??}) for mean occupancy} \tag{9}$$

$$\text{Equations (\textbf{??})-(\textbf{??}) for variance of occupancy} \tag{10}$$

$$\Lambda^a_{i,j} \geq 0 \text{ and integer}, \quad (a = 5,6, i = 1,2,\ldots P,\ j = 1,2,\ldots 7) \tag{11}$$

Equation (3) sets upper and lower bounds on the number of scheduled inductions and scheduled cesareans by time period of day and day of week. Equations (4) and (5) set upper and lower bounds on the number of scheduled inductions and scheduled cesareans by day of week and for the entire week, respectively. The remaining constraints constitute the patient flow portion of the model. Note that the only decision variables are $\Lambda^5_{i,j}$, the number of scheduled inductions, and $\Lambda^6_{i,j}$, the number of scheduled cesareans. The model OB-SMOOTH is a standard mixed integer linear program.

4.1 Computational experiments

Solve realistic problems. No competitive models to which to compare to other than reporting the size of comparable explicit tour scheduling models. I guess I could compare to the 5/7 model for the restricted environment for which it was designed.

5 Just some templates to use

$$\lambda^{h,s(h,m)}_{i,j} = D^{h,r(h,m)}_{i,j} \quad (i = 1,2,\ldots P,\ j = 1,2,\ldots 7, h \in \mathscr{H}, m = 2,3\ldots n_h). \tag{12}$$

6 Conclusions and Future Work

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Table 1: Patient care units

Unit #	Unit Name	Abbr.
1	Labor & Delivery	LD
2	Recovery room	R
3	Cesarean section procedure area	C
4	Postpartum unit	PP