Master Surgical Schedule Planning to Reduce Variability in Post-Operative Ward Bed Demand

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Abstract

Peaks in patients’ demand for inward hospitalization usually lead to disruptions in the provision of healthcare, having negative effects on patient and staff satisfaction. The two main sources of ward bed demand are the emergency department and the surgical center; while the former is random by nature, the latter may be managed through proper allocation of surgical specialties to time slots (or blocks) in the center’s timetable (or Master Surgical Schedule – MSS), and efficient scheduling of surgical procedures within time slots across specialties. We propose a three-step method to design an MSS timetable. In step 1, we mine historical data to determine the average duration of surgical procedures and the average length of stay in wards required by each surgical specialty. In step 2, we use a genetic algorithm to determine a good quality timetable that minimizes the ward bed demand variability overall specialties. In step 3, we approximate the new timetable to the one currently in use at the hospital through a refinement heuristic. Our propositions were tested using data from a tertiary public teaching hospital. The resulting timetable reduced post-operative ward bed demand variability by 99.9%, keeping 97% of surgical specialties allocated in their original slots. To the best of our knowledge, this is the first method for long-term MSS design that reduces post-operative ward bed demand variability and changes in allocations in the current surgical center’s timetable. We innovate by considering the hospital's current timetable to search for solutions promoting minimum changes to the surgical center’s operation.

Full Text

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Tables

Table 1. List of surgical specialties and associated relevant information

<i>Specialty,</i>							
1. Pediatrics	PED	2963	1403.36	361.1	12	1.65	386.01
2. Colorectal	CRT	2516	651.46	178.6	8	3.52	382.48
3. Neurosurgery	NEU	2392	637.57	137.3	10	4.05	430.79
4. Digestive System	DIG	9930	528.73	141.8	23	3.4	299.73
5. Urology	URO	11136	526.64	136.4	25	2.63	231.17
6. Vascular	VAS	3435	525.74	130.1	12	3.03	265.32
7. Plastic	PLA	1663	493.35	161.7	8	3.63	298.23
8. Thoracic	THO	3213	458.63	88.0	10	3.48	266.07
9. Private	PRI	14949	419.84	98.7	48	3.22	225.76
10. General	GEN	9294	377.37	101.2	22	3.03	190.38
11. Orthopedics and Traumatology	ORT	6468	312.08	71.1	22	3.18	165.37
12. Gynecology and Obstetrics	OBG	5398	210.51	85.6	18	2.61	91.4
13. Otorhino	OTR	5652	204.33	43.6	18	2.96	100.82
14. Oral and Maxillofacial	OMF	278	178.84	23.7	2	3.9	116.36
15. Mastology	MAS	2034	72.57	18.4	6	2.93	35.48
16. Undefined	Und	0	0	0	86	0	0

Table 2. Current surgical center's timetable

		Week 1					Week 2				
Room	Shift	Mon	Tue	Wed	Thu	Fri	Mon	Tue	Wed	Thu	Fri
1	<i>M</i>	PRI	PLA	THO	OMF	PLA	PRI	PLA	THO	GEN	PLA
	<i>A</i>	PRI	PLA	THO	OMF	PLA	PRI	PLA	THO	GEN	PLA
	<i>E</i>	PRI					PRI				
2	<i>M</i>	GEN	DIG		OBG	URO	GEN	DIG		OBG	URO
	<i>A</i>	PRI	PRI				PRI	PRI			
	<i>E</i>										
3	<i>M</i>	OBG	OBG	MAS	OBG	OBG	OBG	OBG	MAS	OBG	OBG
	<i>A</i>	OBG	OBG	MAS	OBG	OBG	OBG	OBG	MAS	OBG	OBG
	<i>E</i>										
4	<i>M</i>	VAS	ORT	ORT	ORT	NEU	VAS	ORT	ORT	ORT	NEU
	<i>A</i>	ORT	ORT	ORT	ORT	NEU	ORT	ORT	ORT	ORT	NEU
	<i>E</i>	PRI	ORT				PRI	ORT			
5	<i>M</i>	DIG	DIG	DIG	GEN	PRI	DIG	DIG	DIG	GEN	PRI
	<i>A</i>	DIG	DIG	GEN	GEN	PRI	DIG	DIG	GEN	GEN	PRI
	<i>E</i>					PRI					PRI
6	<i>M</i>	PED	PRI	PED	VAS	PED	PED	PRI	URO	VAS	PED
	<i>A</i>	PED	PRI	PED	DIG	PRI	PED	PRI	PED	PED	PRI
	<i>E</i>		PRI	PED				PRI	PED		
7	<i>M</i>	OTR	GEN	OTR	OTR	OTR	OTR	GEN	OTR	OTR	OTR
	<i>A</i>	OTR	OTR	OTR	OTR	OTR	OTR	OTR	OTR	OTR	OTR
	<i>E</i>										
8	<i>M</i>	URO	URO	PRI	URO	URO	URO	URO	PRI	URO	URO
	<i>A</i>	URO	URO	PRI	PRI	URO	URO	URO	PRI	PRI	URO
	<i>E</i>	URO		PRI	PRI		URO		PRI	PRI	
10	<i>M</i>	ORT	VAS	DIG	GEN	URO	ORT	VAS	DIG	GEN	URO
	<i>A</i>	VAS	ORT	DIG	GEN	URO	VAS	ORT	DIG	GEN	URO
	<i>E</i>	URO	PRI		DIG		URO	PRI		DIG	
11	<i>M</i>	CRT	DIG	CRT	CRT	THO	CRT	DIG	CRT	CRT	THO

	<i>A</i>	MAS	DIG	THO	CRT	THO	MAS	DIG	THO	CRT	THO
	<i>E</i>										
13	<i>M</i>	GEN	GEN	NEU	ORT	VAS	GEN	GEN	NEU	ORT	VAS
	<i>A</i>	GEN	NEU	PRI	PRI	VAS	GEN	NEU	PRI	PRI	VAS
	<i>E</i>		NEU	PRI	PRI	PRI		NEU	PRI	PRI	PRI

Table 3. Timetable I (T-I)

		Week 1					Week 2				
Room	Shift	Mon	Tue	Wed	Thu	Fri	Mon	Tue	Wed	Thu	Fri
1	M	PRI	PLA	THO	URO*	PLA	PRI	THO*	GEN*	GEN	PLA
	A	PRI	OTR*	THO	URO*	MAS*	PRI	THO*	GEN*	GEN	PLA
	E	PRI					PRI				
2	M	GEN	DIG		OBG	URO	GEN	DIG		OBG	URO
	A	PRI	PRI				PRI	PRI			
	E										
3	M	OBG	OBG	MAS	OBG	OBG	OBG	OBG	OBG*	ORT	OBG
	A	PRI*	*	OBG*	OBG	OTR*	OBG	OBG	OBG*	ORT	OBG
	E										
4	M	VAS	ORT	ORT	ORT	NEU	THO*	ORT	GEN*	ORT	NEU
	A	ORT	ORT	ORT	ORT	NEU	THO*	MAS*	GEN*	ORT	DIG*
	E	PRI	ORT				PRI	MAS*			
5	M	DIG	DIG	DIG	GEN	PRI	DIG	DIG	DIG	GEN	PRI
	A	VAS*	DIG	GEN	GEN	PRI	DIG	DIG	GEN	DIG	PRI
	E					PRI					PRI
6	M	NEU*	PRI	PED	VAS	PED	PED	PRI	URO	VAS	PED
	A	NEU*	PRI	PLA*	DIG	PRI	DIG*	PRI	PED	PED	PRI
	E		PRI	VAS*				PRI	PED		
7	M	THO*	OMF*	OTR	OTR	OTR	OTR	GEN	OTR	OTR	OTR
	A	*	OTR	OTR	OTR	OTR	OTR	OTR	URO*	OTR	OTR
	E			GEN*						OTR	
8	M	URO	URO	PRI	URO	URO	URO	PRI*	PRI	URO	URO
	A	URO	MAS*	PRI	PRI	URO	THO*	*	PRI	PRI	URO
	E	URO		PRI	PRI		THO*		PRI	PRI	
10	M	ORT	VAS	URO*	GEN	ORT*	NEU*	CRT*	DIG	PLA	URO
	A	VAS	ORT	URO*	GEN	ORT*	NEU*	*	URO*	PLA	DIG*
	E	CRT*	PRI	PRI*	DIG	ORT*	*	PRI		DIG	
11	M	CRT	DIG	CRT	URO*	GEN*	PLA*	PED*	VAS*	CRT	ORT*

	<i>A</i>	MAS	DIG	OBG*	URO*	GEN*	*	PED*	VAS*	CRT	ORT*
	<i>E</i>			OBG*	URO*	GEN*				OMF	PRI*
13	<i>M</i>	GEN	PED*	NEU	DIG*	VAS*	GEN	*	URO*	ORT	VAS
	<i>A</i>	ORT*	PED*	PRI	DIG*	CRT*	PRI*	NEU	PRI	PRI	VAS
	<i>E</i>		*	PRI	PED*	CRT*		NEU	*	THO	PRI

*: Unmatched slots with respect to current timetable

Table 4. Timetable II (T-II)

		Week 1					Week 2				
Room	Shift	Mon	Tue	Wed	Thu	Fri	Mon	Tue	Wed	Thu	Fri
1	<i>M</i>	PRI	PLA	THO	PED*	PLA	PRI	PLA	THO	GEN	PLA
	<i>A</i>	PRI	PLA	*	OMF	PLA	PRI	PLA	THO	GEN	PLA
	<i>E</i>	PRI					PRI				
2	<i>M</i>	GEN	DIG		OBG	URO	GEN	DIG		OBG	URO
	<i>A</i>	PRI	PRI				PRI	PRI			
	<i>E</i>										
3	<i>M</i>	OBG	OBG	MAS	OBG	OBG	OBG	OBG	MAS	OBG	OBG
	<i>A</i>	OBG	OBG	MAS	OBG	OBG	OBG	OBG	MAS	OBG	OBG
	<i>E</i>										
4	<i>M</i>	VAS	ORT	ORT	ORT	NEU	VAS	ORT	ORT	ORT	NEU
	<i>A</i>	ORT	ORT	ORT	ORT	NEU	ORT	ORT	ORT	ORT	NEU
	<i>E</i>	PRI	ORT				PRI	ORT			
5	<i>M</i>	DIG	DIG	DIG	GEN	PRI	DIG	DIG	DIG	GEN	PRI
	<i>A</i>	DIG	DIG	GEN	GEN	PRI	DIG	DIG	GEN	GEN	PRI
	<i>E</i>					PRI					PRI
6	<i>M</i>	ORT*	PRI	PED	VAS	PED	PED	PRI	URO	VAS	PED
	<i>A</i>	OTR*	PRI	PED	DIG	PRI	OMF*	PRI	PED	PED	PRI
	<i>E</i>		PRI	PED				PRI	PED		
7	<i>M</i>	OTR	GEN	OTR	OTR	OTR	OTR	GEN	OTR	OTR	OTR
	<i>A</i>	OTR	OTR	OTR	OTR	OTR	OTR	OTR	OTR	PED*	OTR
	<i>E</i>										
8	<i>M</i>	URO	URO	PRI	URO	URO	URO	URO	PRI	URO	URO
	<i>A</i>	URO	URO	PRI	PRI	URO	URO	URO	PRI	PRI	URO
	<i>E</i>	URO		PRI	PRI		URO		PRI	PRI	
10	<i>M</i>	ORT	VAS	DIG	GEN	URO	ORT	VAS	DIG	GEN	URO
	<i>A</i>	VAS	ORT	DIG	GEN	URO	VAS	ORT	DIG	GEN	URO
	<i>E</i>	URO	PRI		DIG		URO	PRI		DIG	
11	<i>M</i>	CRT	DIG	CRT	CRT	THO	CRT	DIG	CRT	CRT	THO

	<i>A</i>	THO*	DIG	MAS*	CRT	THO	MAS	DIG	THO	CRT	THO
	<i>E</i>										
13	<i>M</i>	GEN	GEN	NEU	PED*	VAS	GEN	GEN	NEU	ORT	VAS
	<i>A</i>	GEN	NEU	PRI	PRI	VAS	GEN	NEU	PRI	PRI	VAS
	<i>E</i>	THO*	NEU	PRI	PRI	PRI		NEU	PRI	PRI	PRI

*: Unmatched slots with respect to current timetable

Table 5. Comparison between CT, T-I and T-II

	Current timetable	Timetable I	Timetable II
Average	11,218	11,218	11,218
Standard Deviation	999	3.5	97.4
Coefficient of Variation	8.9%	0.03%	0.9%
Variance	998,222	12.3	9,497
Minimum	8,936	11,214	10,987
Maximum	12,431	11,224	11,407
Range	3,495	10	420

Figures

Figure 1

Chromosome encoding using data from the current timetable

Figure 2

Network depicting a surgical center with 3 ORs working 3 shifts during 5 weekdays

Figure 3

Variance in post-operative demand for bed hours as a function of NMS in the timetable

Figure 4

Histogram of daily demand for post-operative bed hours in CT, T-I and T-II

Supplementary Files

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