

Simulating a Medical Observation Unit for a Pediatric Emergency Department

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- Background
- Goals
- Methods
- Results
- Future Work

What is an Observation Unit?

- Dedicated area for Emergency Department (ED)
- Patients need extended time period (<24 hours)
 - Evaluation
 - Monitoring
 - Treatments and patients' response
- Too sick to leave, not sick enough to be admitted

Why Observation?

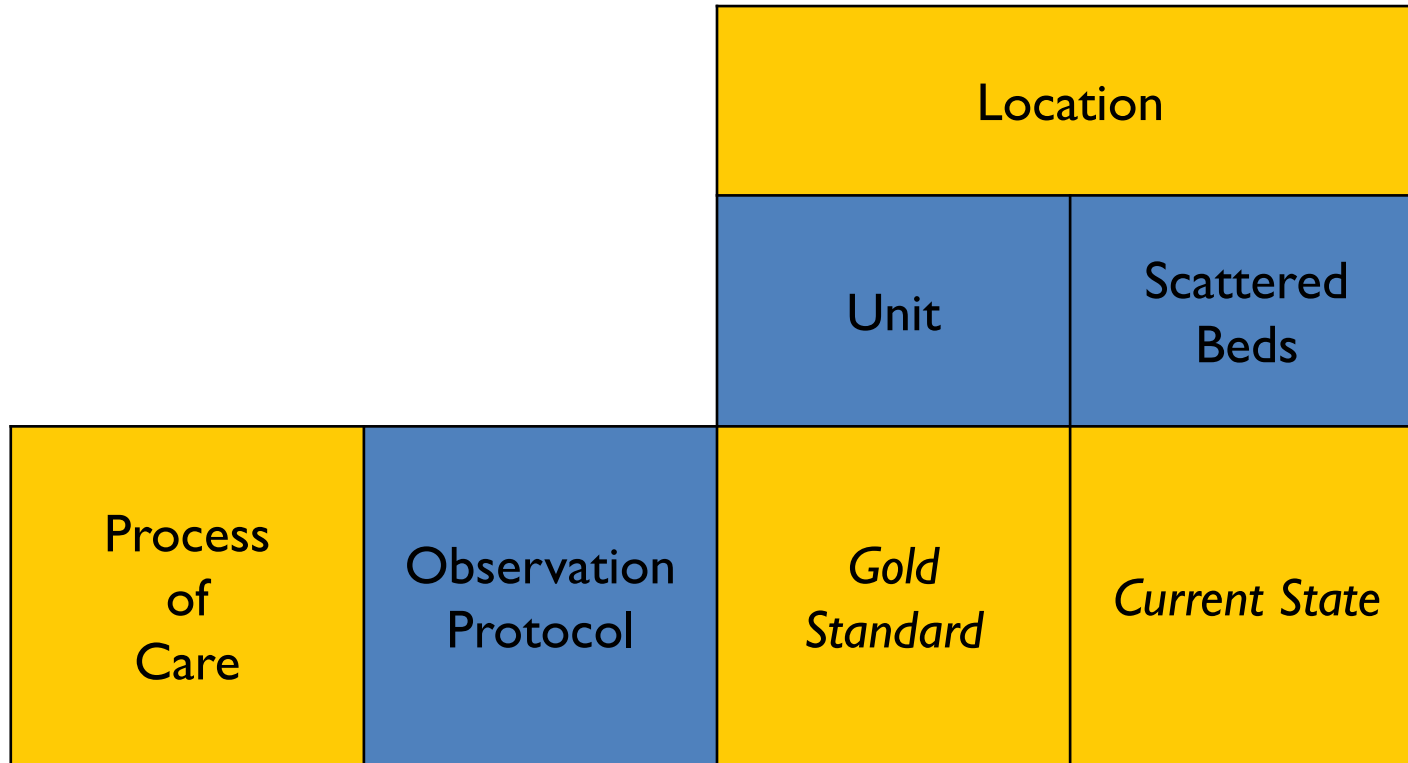
- Benefits:
 - Improved quality of care
 - Decreased ED revisits
 - Decreased readmission rates
 - Shorter lengths of stay
 - Reduced health care costs



- Children's Emergency Services
- 28 ED beds
- Over 25,000 visits per year
- No observation unit
 - Use observation protocol



How Observation can be Structured



- Determine how an observation unit would benefit the Mott ED
 - How many beds?
 - What policies should be implemented?

How Many Beds?

- Little's Law
 - Determine occupancy rate
- Formula: $L = \lambda W$
 - L : average number of patients in the ED
 - λ : arrival rate of patients
 - W : time spent in the system; length of stay (LOS); throughput

How Many Beds?

- To determine the observation unit size N_0 , we had to tweak Little's Law a bit
 - λ = entire throughput of patients/day (63.16)
 - Solution: multiply λ by f_0
 - f_0 = the fraction of patients/day who are put on observation status (.06)
- Final Formulation Used:
$$N_0 = (f_0 \lambda LOS_0) / (\text{Utilization Rate})$$

How Many Beds?

- Need to define Length of Stay (LOS)

Input	Definition	Value (Average)
LOS_{obs}	Time between the start of protocol and hospital discharge	0.47 days
LOS_{total}	Time from ED arrival to ED exit (discharge or admit to inpatient)	0.85 days

How Many Beds?

- Assume utilization rate of .9

Input	Definition	Value	Results
LOS_{obs}	Time between the start of observation protocol and leaving ED	0.47 days	$N_0 = 2.3$ beds ~3 beds
LOS_{total}	Time from ED arrival to ED departure (discharge or admit)	0.85 days	$N_0 = 3.8$ beds ~4 beds

$$N_0 = (f_0 \lambda LOS_0) / (\text{Utilization Rate})$$

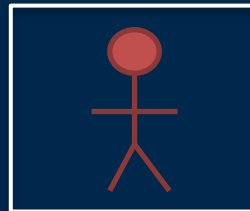
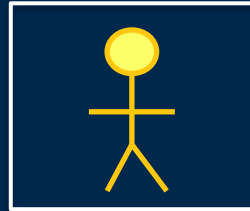
How to Use the Observation Unit?

- Designed for observation patients
- Allows for boarding patients
 - Patient taking up ED bed
- Time to First Treatment vs. Wait Time to Enter Observation Unit
- How do certain policies affect patients?



ED

Observation Unit

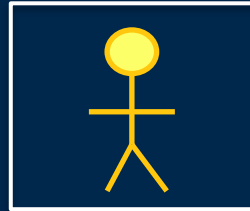


Entrance

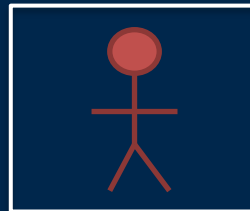
Blue = ED Patient
 Yellow = Observation Patient
 Red = Boarding Patient



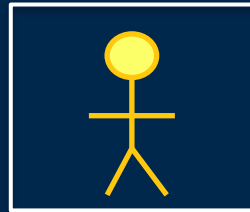
ED



Observation Unit



Entrance



Blue = ED Patient

Yellow = Observation Patient

Red = Boarding Patient

- Tradeoffs
 - Time to first treatment in ED
 - Wait time to enter observation unit
- Arrival times for patients
 - By hour of day
 - By day of week
- Treatment Time (ED and observation)
- Boarding Time
 - Based on time of day

- Parameters
 - Number of ED beds
 - Number of observation beds
 - Threshold of ED patients for boarding
 - Number of observation beds for boarding patients

- Baseline
 - ED beds: 20
 - Observation beds: 2
 - ED Boarding Threshold: 18
 - Observation Beds for Boarding Patients: 0

Baseline Results

- ED Beds: 20
- Observation Beds: 2

- ED Threshold: 18
- Beds for Boarding: 0

Time to First Treatment (mins)

Hour of Day	S	M	Tu	W	Th	F	S
0	1.72	3.55	2.16	4.23	1.26	2.49	2.47
1	0.84	1.89	0.65	1.78	0.51	1.35	0.89
2	0.27	0.64	0.25	0.65	0.21	0.62	0.37
3	0.13	0.25	0.09	0.19	0.03	0.12	0.12
4	0.04	0.07	0.04	0.10	0.03	0.05	0.06
5	0.00	0.04	0.03	0.02	0.01	0.00	0.02
6	0.00	0.02	0.00	0.00	0.01	0.01	0.01
7	0.00	0.01	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.01	0.00	0.00	0.00	0.00	0.00
11	0.00	0.02	0.01	0.01	0.02	0.01	0.02
12	0.01	0.06	0.04	0.06	0.11	0.04	0.05
13	0.08	0.25	0.08	0.12	0.20	0.18	0.18
14	0.22	0.46	0.13	0.36	0.35	0.41	0.31
15	0.30	0.61	0.22	0.70	0.34	0.65	0.59
16	0.59	0.85	0.46	1.00	0.57	0.89	1.20
17	1.44	1.47	0.97	1.45	1.04	1.19	2.35
18	2.83	2.46	1.86	2.15	1.51	2.40	3.42
19	5.17	3.29	4.14	3.20	2.81	4.25	3.70
20	7.22	3.88	7.52	3.50	5.00	5.78	4.04
21	8.19	5.06	9.92	3.66	6.25	6.30	4.42
22	8.45	5.37	9.71	3.64	5.38	5.88	3.92
23	6.15	4.02	7.64	2.60	4.10	4.26	2.68

Wait Time to Enter Observation Unit (mins)

Hour of Day	S	M	Tu	W	Th	F	S
0	51.12	55.49	54.00	53.26	52.03	50.27	52.74
1	47.48	52.02	48.75	55.05	47.47	48.56	53.65
2	48.64	50.17	48.79	48.03	46.84	50.99	46.24
3	43.94	44.93	41.32	45.19	38.86	48.72	45.49
4	37.33	41.76	42.38	41.50	41.17	41.76	42.10
5	35.68	39.19	38.54	38.30	38.24	38.66	37.12
6	37.07	35.44	36.88	35.16	28.20	34.72	35.98
7	31.04	30.91	32.55	31.43	25.25	31.03	26.98
8	20.66	31.65	26.41	24.02	22.40	27.46	26.16
9	24.49	22.53	21.68	20.78	21.29	26.15	26.11
10	20.21	24.08	21.97	23.52	22.45	25.59	19.27
11	19.36	24.41	20.63	20.53	20.01	19.42	23.40
12	23.73	21.22	24.37	24.65	22.28	24.02	24.04
13	21.49	25.64	26.07	22.02	22.63	23.57	25.40
14	26.76	26.91	26.42	26.46	26.83	28.66	30.21
15	26.50	31.74	30.70	28.74	31.19	30.18	31.29
16	30.73	36.85	32.57	37.51	31.41	35.25	37.36
17	33.65	37.12	33.30	37.35	38.08	39.12	37.70
18	39.74	39.49	38.92	40.68	41.22	39.59	39.46
19	41.35	44.23	41.46	46.55	42.24	42.20	46.26
20	46.44	47.65	45.12	46.11	45.06	46.00	45.89
21	51.57	48.60	51.34	47.47	47.92	49.13	48.29
22	53.65	52.32	51.92	49.86	52.03	53.86	50.26
23	56.58	53.64	51.99	50.56	50.74	52.88	51.15

Scenario 1: More Observation Beds

- ED Beds: 20
- Observation Beds: 4
- ED Threshold: 18
- Beds for Boarding: 0

Time to First Treatment (mins)

Hour of Day	S	M	Tu	W	Th	F	S
0	1.72	3.55	2.16	4.23	1.26	2.49	2.47
1	0.84	1.89	0.65	1.78	0.51	1.35	0.89
2	0.27	0.64	0.25	0.65	0.21	0.62	0.37
3	0.13	0.25	0.09	0.19	0.03	0.12	0.12
4	0.04	0.07	0.04	0.10	0.03	0.05	0.06
5	0.00	0.04	0.03	0.02	0.01	0.00	0.02
6	0.00	0.02	0.00	0.00	0.01	0.01	0.01
7	0.00	0.01	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.01	0.00	0.00	0.00	0.00	0.00
11	0.00	0.02	0.01	0.01	0.02	0.01	0.02
12	0.01	0.06	0.04	0.06	0.11	0.04	0.05
13	0.08	0.25	0.08	0.12	0.20	0.18	0.18
14	0.22	0.46	0.13	0.36	0.35	0.41	0.31
15	0.30	0.61	0.22	0.70	0.34	0.65	0.59
16	0.59	0.85	0.46	1.00	0.57	0.89	1.20
17	1.44	1.47	0.97	1.45	1.04	1.19	2.35
18	2.83	2.46	1.86	2.15	1.51	2.40	3.42
19	5.17	3.29	4.14	3.20	2.81	4.25	3.70
20	7.22	3.88	7.52	3.50	5.00	5.78	4.04
21	8.19	5.06	9.92	3.66	6.25	6.30	4.42
22	8.45	5.37	9.71	3.64	5.38	5.88	3.92
23	6.15	4.02	7.64	2.60	4.10	4.26	2.68

Time to First Treatment (mins)

Hour of Day	S	M	Tu	W	Th	F	S
0	0.84	2.22	1.30	2.64	0.69	1.53	1.30
1	0.40	0.96	0.40	0.84	0.22	0.69	0.55
2	0.14	0.42	0.12	0.25	0.06	0.32	0.11
3	0.04	0.10	0.02	0.05	0.01	0.08	0.05
4	0.01	0.03	0.00	0.00	0.00	0.00	0.00
5	0.00	0.01	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.01	0.00	0.00
12	0.01	0.02	0.02	0.01	0.05	0.02	0.02
13	0.06	0.15	0.05	0.08	0.12	0.09	0.05
14	0.12	0.31	0.07	0.23	0.16	0.26	0.16
15	0.22	0.31	0.09	0.49	0.19	0.45	0.36
16	0.43	0.47	0.27	0.64	0.28	0.65	0.77
17	1.05	0.91	0.62	0.82	0.63	0.87	1.67
18	2.21	1.66	1.35	1.45	1.12	1.74	2.54
19	3.87	2.28	2.99	2.15	2.03	3.29	2.47
20	5.49	2.71	5.61	2.32	3.90	4.55	2.69
21	5.93	3.61	7.45	2.33	4.54	4.72	2.85
22	5.94	3.87	7.09	2.37	3.73	4.05	2.64
23	4.32	2.57	5.27	1.46	2.61	2.78	1.77

Scenario I: More Observation Beds

- ED Beds: 20
- Observation Beds: 4
- ED Threshold: 18
- Beds for Boarding: 0

Wait Time to Enter Observation Unit (mins)

	S	M	Tu	W	Th	F	S
0	51.12	55.49	54.00	53.26	52.03	50.27	52.74
1	47.48	52.02	48.75	55.05	47.47	48.56	53.65
2	48.64	50.17	48.79	48.03	46.84	50.99	46.24
3	43.94	44.93	41.32	45.19	38.86	48.72	45.49
4	37.33	41.76	42.38	41.50	41.17	41.76	42.10
5	35.68	39.19	38.54	38.30	38.24	38.66	37.12
6	37.07	35.44	36.88	35.16	28.20	34.72	35.98
7	31.04	30.91	32.55	31.43	25.25	31.03	26.98
8	20.66	31.65	26.41	24.02	22.40	27.46	26.16
9	24.49	22.53	21.68	20.78	21.29	26.15	26.11
10	20.21	24.08	21.97	23.52	22.45	25.59	19.27
11	19.36	24.41	20.63	20.53	20.01	19.42	23.40
12	23.73	21.22	24.37	24.65	22.28	24.02	24.04
13	21.49	25.64	26.07	22.02	22.63	23.57	25.40
14	26.76	26.91	26.42	26.46	26.83	28.66	30.21
15	26.50	31.74	30.70	28.74	31.19	30.18	31.29
16	30.73	36.85	32.57	37.51	31.41	35.25	37.36
17	33.65	37.12	33.30	37.35	38.08	39.12	37.70
18	39.74	39.49	38.92	40.68	41.22	39.59	39.46
19	41.35	44.23	41.46	46.55	42.24	42.20	46.26
20	46.44	47.65	45.12	46.11	45.06	46.00	45.89
21	51.57	48.60	51.34	47.47	47.92	49.13	48.29
22	53.65	52.32	51.92	49.86	52.03	53.86	50.26
23	56.58	53.64	51.99	50.56	50.74	52.88	51.15

Wait Time to Enter Observation Unit (mins)

	S	M	Tu	W	Th	F	S
0	6.43	7.01	6.82	6.80	6.89	7.00	6.83
1	7.08	7.23	7.56	6.73	5.89	7.14	6.46
2	6.84	6.91	5.78	7.36	5.85	5.95	7.35
3	5.96	5.95	4.71	6.72	3.99	5.80	5.60
4	4.68	4.68	4.24	4.40	3.92	3.91	4.52
5	3.11	3.64	4.27	3.49	3.49	4.07	4.22
6	3.05	2.95	2.12	2.87	1.97	2.48	1.75
7	2.63	3.33	1.88	1.96	1.73	3.60	1.78
8	0.80	2.64	1.38	2.09	3.12	1.86	2.13
9	1.17	0.96	1.01	1.33	1.00	0.91	1.12
10	1.45	0.96	0.69	1.76	0.29	1.57	1.36
11	0.23	0.56	0.50	1.06	1.04	0.90	0.40
12	0.26	1.57	0.83	1.32	0.76	1.26	1.35
13	1.28	1.16	1.00	1.16	0.96	1.23	0.84
14	1.18	2.05	0.98	1.09	1.33	1.15	1.16
15	1.09	2.43	1.31	1.72	1.27	1.86	1.70
16	1.33	2.16	1.31	1.95	1.73	2.60	2.11
17	2.13	3.01	1.41	2.38	1.63	2.36	2.85
18	2.85	3.03	1.80	3.89	2.31	3.39	3.54
19	3.48	3.60	2.74	3.53	3.62	3.35	3.81
20	4.45	4.11	3.69	4.80	4.27	5.50	3.93
21	4.82	4.57	4.75	6.66	3.42	5.23	5.46
22	5.12	5.53	5.87	5.25	6.41	7.11	5.91
23	7.67	5.70	6.95	5.44	6.27	6.06	6.78

Scenario 2: Adding Flexibility

- ED Beds: 20
- Observation Beds: 4
- ED Threshold: 18
- Beds for Boarding: 4

Time to First Treatment (mins)

Hour of Day

	S	M	Tu	W	Th	F	S
0	0.84	2.22	1.30	2.64	0.69	1.53	1.30
1	0.40	0.96	0.40	0.84	0.22	0.69	0.55
2	0.14	0.42	0.12	0.25	0.06	0.32	0.11
3	0.04	0.10	0.02	0.05	0.01	0.08	0.05
4	0.01	0.03	0.00	0.00	0.00	0.00	0.00
5	0.00	0.01	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.01	0.00	0.00
12	0.01	0.02	0.02	0.01	0.05	0.02	0.02
13	0.06	0.15	0.05	0.08	0.12	0.09	0.05
14	0.12	0.31	0.07	0.23	0.16	0.26	0.16
15	0.22	0.31	0.09	0.49	0.19	0.45	0.36
16	0.43	0.47	0.27	0.64	0.28	0.65	0.77
17	1.05	0.91	0.62	0.82	0.63	0.87	1.67
18	2.21	1.66	1.35	1.45	1.12	1.74	2.54
19	3.87	2.28	2.99	2.15	2.03	3.29	2.47
20	5.49	2.71	5.61	2.32	3.90	4.55	2.69
21	5.93	3.61	7.45	2.33	4.54	4.72	2.85
22	5.94	3.87	7.09	2.37	3.73	4.05	2.64
23	4.32	2.57	5.27	1.46	2.61	2.78	1.77

Time to First Treatment (mins)

Hour of Day

	S	M	Tu	W	Th	F	S
0	0.33	1.10	0.64	1.23	0.31	0.68	0.49
1	0.12	0.42	0.13	0.37	0.07	0.27	0.13
2	0.02	0.08	0.04	0.07	0.01	0.12	0.03
3	0.01	0.01	0.01	0.00	0.00	0.02	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.01	0.02	0.01	0.00	0.03	0.02	0.02
13	0.02	0.08	0.02	0.03	0.06	0.07	0.03
14	0.06	0.12	0.03	0.10	0.11	0.17	0.10
15	0.12	0.14	0.05	0.28	0.09	0.28	0.22
16	0.23	0.27	0.17	0.35	0.14	0.36	0.52
17	0.57	0.57	0.37	0.46	0.40	0.46	1.10
18	1.29	1.06	0.81	0.80	0.57	1.04	1.56
19	2.51	1.32	1.92	1.20	1.10	1.97	1.34
20	3.35	1.53	3.66	1.37	2.26	2.61	1.44
21	3.53	1.99	4.67	1.28	2.61	2.59	1.59
22	3.46	2.21	4.29	1.28	1.94	2.26	1.40
23	2.25	1.56	2.82	0.70	1.31	1.29	0.81

Scenario 2: Adding Flexibility

- ED Beds: 20
- Observation Beds: 4
- ED Threshold: 18
- Beds for Boarding: 4

Wait Time to Enter Observation Unit (mins)

Hour of Day	S	M	Tu	W	Th	F	S
0	6.43	7.01	6.82	6.80	6.89	7.00	6.83
1	7.08	7.23	7.56	6.73	5.89	7.14	6.46
2	6.84	6.91	5.78	7.36	5.85	5.95	7.35
3	5.96	5.95	4.71	6.72	3.99	5.80	5.60
4	4.68	4.68	4.24	4.40	3.92	3.91	4.52
5	3.11	3.64	4.27	3.49	3.49	4.07	4.22
6	3.05	2.95	2.12	2.87	1.97	2.48	1.75
7	2.63	3.33	1.88	1.96	1.73	3.60	1.78
8	0.80	2.64	1.38	2.09	3.12	1.86	2.13
9	1.17	0.96	1.01	1.33	1.00	0.91	1.12
10	1.45	0.96	0.69	1.76	0.29	1.57	1.36
11	0.23	0.56	0.50	1.06	1.04	0.90	0.40
12	0.26	1.57	0.83	1.32	0.76	1.26	1.35
13	1.28	1.16	1.00	1.16	0.96	1.23	0.84
14	1.18	2.05	0.98	1.09	1.33	1.15	1.16
15	1.09	2.43	1.31	1.72	1.27	1.86	1.70
16	1.33	2.16	1.31	1.95	1.73	2.60	2.11
17	2.13	3.01	1.41	2.38	1.63	2.36	2.85
18	2.85	3.03	1.80	3.89	2.31	3.39	3.54
19	3.48	3.60	2.74	3.53	3.62	3.35	3.81
20	4.45	4.11	3.69	4.80	4.27	5.50	3.93
21	4.82	4.57	4.75	6.66	3.42	5.23	5.46
22	5.12	5.53	5.87	5.25	6.41	7.11	5.91
23	7.67	5.70	6.95	5.44	6.27	6.06	6.78

Wait Time to Enter Observation Unit (mins)

Hour of Day	S	M	Tu	W	Th	F	S
0	7.53	9.60	9.22	10.50	7.57	7.61	8.36
1	5.76	8.04	8.08	7.90	6.21	8.31	7.85
2	5.58	7.38	6.28	7.90	6.08	6.93	6.78
3	6.96	5.81	6.17	6.07	4.22	6.67	5.29
4	4.87	4.44	4.27	4.56	4.00	5.27	3.73
5	3.89	3.49	3.56	5.21	3.00	5.46	2.85
6	2.39	2.75	2.44	2.85	1.32	2.85	3.50
7	1.86	2.38	2.12	1.56	1.18	2.83	2.75
8	1.69	1.67	1.09	1.02	0.88	1.98	1.34
9	1.12	0.75	1.14	1.28	1.01	1.09	1.13
10	1.22	0.79	1.03	1.44	0.63	1.14	0.89
11	0.60	0.61	0.60	1.35	0.25	1.48	0.92
12	0.42	1.04	1.07	0.87	1.35	0.72	1.17
13	0.72	1.45	0.99	0.75	1.21	1.92	1.09
14	1.46	1.89	1.61	2.01	1.42	2.00	1.91
15	1.86	2.57	1.60	1.73	2.16	2.27	2.16
16	2.11	2.77	1.90	2.47	2.66	2.72	2.89
17	3.34	3.83	3.29	3.85	4.07	4.56	4.04
18	4.23	4.56	3.50	5.17	3.67	4.33	5.26
19	6.16	6.37	4.96	5.34	4.82	5.77	6.53
20	7.84	6.90	6.79	7.41	7.06	7.21	7.89
21	8.70	6.87	8.98	7.59	7.61	8.54	7.59
22	10.44	9.34	9.63	7.25	8.27	9.85	8.41
23	10.42	8.83	10.33	8.22	8.30	8.38	9.94

- Flexibility
 - Allows for short first treatment time
 - Increases time to get into observation unit
- Small observation units need restricted beds

- Change parameters
 - Capacities and thresholds
- Modify observation patients
- Other methods to determine how many beds

- Center for Healthcare Engineering and Patient Safety (CHEPS)
- C.S. Mott Children's Hospital
- The Seth Bonder Foundation
- The U of M Center for Research on Learning and Teaching (CRLT)
- The TDC Foundation

Thank You! Questions?

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