Computer Simulation of Patient Flow within an Emergency Department to Plan Room Numbers and Configuration to Optimize Patient Waiting Time and Turnaround Time

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Problem: Waiting times for patients to be seen at the Champlain Valley Physicians Hospital in Plattsburgh, New York were rated as excessive in patient satisfaction surveys undertaken by the hospital as part of ongoing quality assurance review. Data were collected for patient flow for a random week in February to assess individual variation in physician contact time, waiting time for laboratory results, waiting time for X-ray procedures and analysis, and waiting time both before entering an examination room and while in an examination room. Data were obtained on all emergency department visits for the peak month of September and for a lower flow month of October to allow assessment of the range of variation from highest flow to average flow.

Methods: A computer model was created using the systems dynamics methods of mathematical computer modeling and the Stella II software system (High Performance Systems, Hanover, New Hampshire, 1994). Equations were developed to match observationally determined patient arrival rates for hours of the day and days of the week. The model was tested using the existing configuration of rooms at CVPH (2 critical care, 5 urgent care, and 12 non-urgent care beds). The model was accepted as accurate when it matched patient waiting times and patient turnaround times along with rates of patients admitted and discharged for the heavy volume month of September and the lighter volume month of October. Once the reference data was predicted accurately by the model, changes in numbers of rooms were made to determine what effect this would have on waiting time and turnaround time. An assumption was maded that an improved physical plant would improve lab and X-ray turn around time by 30%. Random additional arrivals were included to better mimic actual conditions. They were increased by 10% over actual arrivals for 1994 to mimic better probable rates in 1996 when the new emergency room would become operational. The model diagram is presented as Appendix I and the model equations as Appendix II.

Results:

Table 1 shows waiting times and turnaround times for July and October--the former a heavy month, the latter, a light month. Minimum and maximum waits are presented. July and September are not significantly different from each other, but statistically shorter time intervals (indicated by "*") are found in October.

Table 1. Waiting times and turnaround times for heavy and average months.

Month	Critical Care	Emergency	Non-urgent	Fast Track
July Turnaround	189.70 [63,743]	198.65 [28,863]	149.21 [10,794]	105.95 [3,253]
July waiting before being seen	0	65.80 [0,265]	86.02 [6,220]	80.28 [14,396]
September turnaround	191.28 [60,830]	208.30 [40,774]	165.95 [5,792]	115.95 [6,258]
September waiting before being seen	0	70.25 [0,255]	84.10 [5,240]	83.86 [0,293]
October Turnaround	169.41* [60,719]	165.80* [33,853]	128.68* [8,886]	84.03* [5,284]
October wait		58.60*	76.65	73.80

before being seen	0	[0,212]	[1,249]	[4,212]

When time of day and alevel of acuity was controlled for, the variation between staff emergency department physicians were non-significant. A tendency was observed, however, for some locum tenems physicians to be outside the usual range of the staff physicians with both longer or shorter turnaround times.

A level of acceptable waiting was established as 0-20 minutes for emergency patients, 10-40 minutes for non-urgent patients, and 20-60 minutes for fast-track patients. Currently the CVPH emergency department has 2 critical care beds, 5 urgent care beds, and 12 non-urgent beds.

Table 2 shows the changes in waiting time for emergency or urgent care cases when the numbers of rooms are changed. The computer simulation model assumes that excess critical care patients will be triaged to urgent care beds and excess urgent care patients will be triaged to non-urgent beds. This is observed in practice at the emergency department.

Table 2. Changes in waiting time and turnaround time for urgent care patients based upon number of beds available.

Number of Critical Care Rooms	Number of Urgent Care Rooms	Number of Nonurgent Care Beds	Waiting time for urgent care (mean, maximum)	Turnaround time for urgent care (mean)
4	10	24	6.2, 32	127.07
3	10	24	11.2, 49	132.92
2	10	24	27.0, 67	142.09
4	8	24	10.2, 40	131.22
3	8	24	12.2, 59	149.62
2	8	24	40.1,75	151.40
4	6	24	8.2, 52	131.11
4	6	22	10.9, 72	134.48
4	6	20	13.1, 96	139.85
4	6	18	13.6, 119	144.83
4	6	16	15.0, 135	145.68
4	6	14	19.5, 160	151.07
3	6	24	18.2, 110	162.34
3	6	22	18.4, 124	164.15
3	6	20	20.2, 139	168.06
3	6	18	28.4, 153	171.26
3	6	16	31.2, 161	176.81
3	6	14	41.2, 178	178.62
2	6	24	44.86, 186	155.66
2	6	22	50.8, 198	186.58
2	6	20	54.1, 210	191.69
2	6	18	58.1, 222	193.57
2	6	16	65.2, 235	200.30
2	6	14	69..4, 241	201.22
2	5	12	70.7, 255	208.30

Table 3 shows waiting times and turnaround times for non-urgent cases.

Table 3. Waiting times and turnaround times for non-urgent cases varying by number of rooms.

Number of Critical Care Rooms	Number of Urgent Care Rooms	Number of Nonurgent Care Beds	Waiting time for nonurgent care	Turnaround time for non-urgent cases

4	10	24	10.0, 60	60.15
3	10	24	20.0, 68	63.58
2	10	24	30.5, 79	69.56
4	8	24	15.1, 69	68.08
3	8	24	21.2, 84	78.91
2	8	24	30.0, 90	80.13
4	6	24	14.1, 101	79.41
4	6	22	21.1, 110	85.95
4	6	20	31.4, 122	95.94
4	6	18	41.2, 131	109.74
4	6	16	51.1, 148	117.49
4	6	14	68.9, 159	131.11
3	6	24	34.8, 163	132.99
3	6	22	43.1, 172	136.79
3	6	20	52.3, 180	142.98
3	6	18	56.9, 194	149.35
3	6	16	60.9, 199	151.92
3	6	14	70.8, 201	154.38
2	6	24	45.2, 205	132.05
2	6	22	52.2, 210	139.93
2	6	20	53.1, 211	147.07
2	6	18	60.9, 212	151.22
2	6	16	70.7, 223	159.27
2	6	14	80.2, 230	162.02
2	5	12	84.1, 240	165.95

Conclusions. To accomplish the goals for waiting time and turnaround time for the next ten years, the need is for 4 critical care beds, 10 urgent care beds, and a combination of 24 non-urgent care and fast-track beds.

Our review of the literature shows that managed care will not be expected to decrease utilization for insured or Medicaid patients, based upon studies conducted elsewhere. A telephone advice service is one of the few interventions which has decreased utilization, but is difficult to implement in New York, given its malpractice climate. Such a service has shown success in Canada in reducing emergency department utilization.