Chapter 6

Experimentation and Results

The administration of Grace Hospital must constantly evaluate the strengths and weaknesses of new management policies. Using the Grace Hospital Simulation Model, the evaluation of possible future strategies can be done with much more confidence. Four different scenarios of interest to management at Grace were simulated.

1. Increase the load in terms of patients per month.

2. Increase the proportion of patients residing outside of Vancouver.

3. Decrease the average length of stay in the PP.

4. Remove the limit on the number of patients entering the hospital per month (i.e. remove the preregistration cap).

The following performance measures were determined for all the experiments.

10:30 AP census - the average number of patients in the antepartum modules at 10:30 a.m.

days in LOW overflow - the number of total patient days spent in the temporary overflow areas of low risk (e.g. in the assessment room or in the PAR).

10:30 PP census - the average number of patients in the postpartum modules at 10:30 a.m.

patients in TREAT - the number of PP patients temporarily in a treatment room.
days lost in PP - the total number of patient days lost due to early discharge from PP.

Either caused by a red flag condition (see section 4.5.4) or because new patients arrive to find PP totally full.

10:30 OBN census - the average number of babies in the observation nursery at 10:30 a.m.

Note: all tables show percentage increase or decrease from the standard run in brackets.

Of particular interest are the number of patients days spent in temporary overflow from LOW, and the number of patient days lost due to crowding in PP. If these values increase much more than the standard levels, the congestion in the hospital becomes unacceptably high. Patients would be unable to receive the care they require. When examining the results, note that simulation models can show the effects of changing certain inputs, but cannot determine optimal conditions.

All the experiments used a standard run length: 10 months initialization followed by 20 months of data collection. The 20 months of data was then scaled down to one month.

6.1 Increasing the Load

Increasing the patient load per month at Grace can occur in two ways, either more patients could be admitted per month, or the number of days in a month could decrease. The standard run of the model is based on months with 31 days (since July & August 1988 each have 31 days). But, Grace Hospital uses the same preregistration limit regardless of the number of days in the month. Therefore, in months with fewer days, more patients are treated per day. The results in shorter months with the same preregistration limit are shown in Table 6.11. There could be a large effect. For example, in months with 28 days the combined PP and AP average census figures increase by 8.2 patients or 7.5%. If
Table 6.11: Experiment 1A: Decreasing the Number of Days per Month

<table>
<thead>
<tr>
<th></th>
<th>10:30 AP census</th>
<th>days in LOW overflow</th>
<th>10:30 PP census</th>
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<th>days lost in PP</th>
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</tr>
</thead>
<tbody>
<tr>
<td>standard</td>
<td>28.2</td>
<td>3.4</td>
<td>80.7</td>
<td>13.4</td>
<td>25.9</td>
<td>6.6</td>
</tr>
<tr>
<td>30 days</td>
<td>29.2(3.5)</td>
<td>4.7(39)</td>
<td>83(2.8)</td>
<td>23.6(76)</td>
<td>40.3(55)</td>
<td>6.4(-3)</td>
</tr>
<tr>
<td>28 days</td>
<td>31.3(11)</td>
<td>6.4(88)</td>
<td>85.8(6.3)</td>
<td>83.2(522)</td>
<td>89.7(246)</td>
<td>7.0(6)</td>
</tr>
</tbody>
</table>

The load per month were the same in February as in July or August the crowding would be unacceptable. However, maternity demand has a pronounced seasonal variation. This variation was not incorporated in the model because only July and August data were available. February is a slow month at Grace. Even though the preregistration limit is not changed fewer patients come to Grace. On the other hand, some months with 30 days (e.g. September) have a similar demand pattern as July or August. Assuming a similar demand, the effects of not changing the preregistration cap in months with 30 days are noticeable. For example, the number of days lost in PP due to overcrowding increases by 55%. Consequently, it is recommended that the preregistration limit reflect the number of days per month.

Three different experiments were run showing the effects of increasing the number of patients admitted per month. The number of patients arriving to deliver was increased by 10, 20, and 50 per month, with a corresponding percentage increase in the number of AP-only, PP-only, and pediatric patients. Normally about 620 patients per month deliver at Grace, so these increases are relatively small. However, Table 6.12 shows that the increases have a significant effect. For example, only 10 more patients per month causes the number of patients who must temporarily use a treatment room to jump by 114%. Increasing the number of patients per month by 50 raises the combined AP and PP average census by 7%. Both these experiments reflect the fact that that Grace is
already running close to capacity. A relatively small increase in load results in a large decrease in service.

6.2 Increase the Proportion of Patients from Outside Vancouver

Population trends predict that in the coming years there will be a large decrease in the number of births in Vancouver, and an increase in births in the rest of the province. Thus, because of Grace's role as a tertiary care facility, administrators are predicting an increase in the relative proportion of patients from outside Vancouver arriving at Grace. Importantly, this redistribution also results in a higher proportion of “high risk” patients since patients only come from far away if they are likely to develop a complication. To simulate this prediction, two new experiments were run. First, the relative proportion of patients from Vancouver was decreased by 10 percentage points (at present about 55% of patients are from Vancouver proper). The proportion of patients from the GVRHD and B.C. increased by 5 percentage points each. The second experiment decreased the patients from Vancouver by 20 percentage points (down to 35% of total patients) again spreading the increase evenly among the other regions. Both of these experiments did not change the total number of patients arriving to deliver each month. However, the numbers of AP-only, PP-only, and pediatric patients were increased. To reflect the higher


|                | 10:30 AP census | days in LOW overflow | 10:30 PP census | patients in TREAT | days lost in PP | 10:30 OBN census |
|----------------|----------------|---------------------|----------------|------------------|----------------|-----------------
| standard       | 28.2           | 3.4                 | 80.7           | 13.4             | 25.9           | 6.6             |
| 45% Van.       | 28.7(1.8)      | 3.9(15)             | 81.1(0.5)      | 10.8(-24)        | 28.5(10)       | 6.8(3)          |
| 35% Van.       | 29.3(3.9)      | 3.2(-5)             | 81.6(1.1)      | 14.9(11)         | 29.9(15)       | 6.8(3)          |

Table 6.13: Experiment 2: Increasing the Proportion of Patients from Outside Vancouver

... proportion of patients from GVRHD and B.C. that require this additional care. The results are shown in Table 6.13. The impact on the hospital was not very large. For example, with 20 percentage points less patients from Vancouver the combined AP and PP census increased by only 1.8%.

6.3 Decrease the Average Length of Stay

An early discharge program is an effective way to accomplish a decrease in the average LOS in PP. Early discharge programs have an added benefit. Caring for patients in their own homes may be more cost effective and more comfortable for the patient. Two experiments were run to gauge changes in hospital utilization when the average LOS in PP was decreased. At present, the average length of stay in the PP section is 3.1 days for spontaneous deliveries, 3.3 days for instrumental deliveries, and 5.2 days for C-sections. The first experiment decreased the average LOS for spontaneous and instrumental deliveries to 3 days, and decreased the average LOS for C-sections to 5 days. The second experiment further decreased the average LOS for C-sections to 4 days. The results are shown in Table 6.14. As expected the utilization figures for AP, LOW, and OBN did not noticeably change. In contrast, the PP utilization measures changed markedly. For example, lowering the average LOS of C-sections to 4 days decreases the number of days lost in PP due to overcrowding by a very substantial 573%. Even decreasing the average...
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<td>6.6</td>
</tr>
<tr>
<td>5 day CS</td>
<td>28.2(0)</td>
<td>3.8(13)</td>
<td>78.7(-2.5)</td>
<td>7.9(-68)</td>
<td>13.3(-94)</td>
<td>6.7(1.5)</td>
</tr>
<tr>
<td>4 day CS</td>
<td>28.2(0)</td>
<td>3.2(-5)</td>
<td>74.3(-8.6)</td>
<td>1.3(-968)</td>
<td>3.8(-573)</td>
<td>6.6(0)</td>
</tr>
</tbody>
</table>

Table 6.14: Experiment 3: Decrease the Average LOS in PP

LOS of all patients by only about 0.2 days decreases the number of days lost in PP by 94%. This result shows that the benefits of an early discharge program can be substantial. More experiments would be needed to determine how many more patients could be accommodated while maintaining the old utilization level.

6.4 Eliminate the Preregistration Cap

The final experiment demonstrates that Grace could not operate without limiting the number of admissions. In July and August of 1988 an average of 190 patients per month were rejected by the preregistration system. Therefore, the model was run with an

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</tr>
<tr>
<td>nocap</td>
<td>28.8(2.1)</td>
<td>18(532)</td>
<td>90.5(12)</td>
<td>257(1927)</td>
<td>167.4(646)</td>
<td>7.1(7.5)</td>
</tr>
</tbody>
</table>

Table 6.15: Experiment 4: Eliminate the Preregistration Cap

additional 190 patients delivering each month. All patients rejected must be “low risk” since all “high risk” patients are automatically admitted. To minimize their effect, all of these new patients were assigned a spontaneous delivery with no AP or PP complications. This is clearly an underestimate since not all initially diagnosed “low risk” patients will remain complication free. In addition, the experiment did not increase the arrival rates
of the AP-only, PP-only, and pediatric patients that would undoubtedly also occur from this influx of new patients. The results (Table 6.15) are purely academic since Grace would not consider eliminating their highly successful preregistration system. Without the cap the number of patient-days lost in PP due to overcrowding increases by 646%, and the number of visits to the treatment room increases by an incredible 1927%. Clearly the preregistration cap is needed to keep the load at Grace Hospital under control.
Chapter 7

Summary and Conclusion

A successful model of Grace Hospital needs to take into account many complexities, including the interactions among the various units, the progressive nature of the delivery process, and the discharge time distribution. The model was based on a simulation model methodology presented by Cohen, Hershey, and Weiss [5]. It assumes that under no capacity constraints movements depend only on patient's present location, and not on any past history. Overflow results in either patients temporarily staying in an alternative unit, moving to another acceptable unit, or displacing another patient prematurely.

In contrast to previous models, this simulation uses a classification system that varies the factor that governs transfers and LOS depending on a patient's stage of delivery. The phases of treatment in obstetrics are well defined into antepartum, delivery, and postpartum. Classifications in the model include antepartum complication, delivery type, and postpartum complication. For example, in antepartum a patient's behaviour is best determined by her antepartum complication. In the delivery suite, on the other hand, a patient's delivery type is most important. As an additional improvement over past models a patient's LOS in postpartum depends on the time of day at which she enters PP. By including this extra factor in the LOS calculation the model is able to accurately simulate the mid-morning peak load. This addition could be used in other models that simulate hospitals with a similar arrival and discharge pattern.

The model was time consuming to create, and is very complex. However, by conducting numerous interviews at Grace the model was created to accurately reflect the
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operation of the hospital. However, verification and validation were very successful and the model is now a valuable management tool. It has been used to study several scenarios of interest: increasing the load, changing the patient mix, decreasing the LOS, and eliminating the preregistration system. Measures of utilization include the average census, and the number of patient-days spent in inappropriate units or lost due to overcrowding. The results show that Grace is operating very close to capacity. A relatively small increase in load results in a large increase in congestion. Also, an early discharge program was shown to significantly alleviate the overcrowding. The specific numerical results themselves are applicable only to Grace, but the simulation methodology used to overcome problems maybe of interest in other applications. The model will be used to evaluate other prospective changes in management policies.

Grace Hospital is far too complex for a simulation model to include every detail. In fact, a simulation model should include only important and relevant details. However, improvements to the present model may result by including some or all of the following:

1. Staffing considerations - an important factor in day to day operation of a hospital.

2. Seasonal variations in load

3. Scheduling procedure for the operating room - difficult to include in the model of a progressive care hospital.

4. Patient movements to reflect time of day at which they occur

5. Regional effects - especially important for the preregistration system.