Analysis of Clinic Efficiency 
in the Eye Plastics and 
Neuro-Ophthalmology Eye Clinics

Client: Margaret Pennington, Clinic Supervisor

Coordinator: Elizabeth Othman

Kellogg Eye Center
University of Michigan Medical Center
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Consultants:

<table>
<thead>
<tr>
<th>James Armistead, II</th>
<th>David Chan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brian Burk</td>
<td>Laural Wagner</td>
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Executive Summary

Findings:

Interviews were conducted with each of the staff physicians. The staff physicians said that clinic procedure times could not be decreased because the quality of care to the patient would also decrease. The presentation time between staff physician and resident physician also cannot decrease without a decrease in the educational level of the resident physicians.

It was also found through the interviews with the staff physicians and receptionists that there was no standardized scheduling system for the clinics. Each staff physician schedules their patients in a different manner.

The receptionists need to know what procedures the patient experienced during their visit to check them out quickly.

The clinics were first observed by following staff members during clinic activity. When following the staff physicians it seemed that their time was highly utilized. Because each patient coming to the clinic must see the staff physician at least once, and time is scarce for the staff physician, the availability of the staff physician is the limiting factor for throughput in each clinic.

After the initial observations of the clinic, a time study was conducted. Through this study it was found that total wait times were excessive.

From the average clinic times in the time study, return patients were found to take significantly less time than new patients for total procedure time, total wait time, and total time in the clinic.

The percent utilization from the time study of each staff physician showed that staff physician utilization is not as high as it appeared when following the staff physicians through the clinic. A large portion of the unutilized time is due to the fact that when the clinic starts, the staff physician, in general, does not see a patient in the first encounter. The first staff member to see the patient is usually either a resident physician, or a technician.

The time study also does not take into account time the staff physician spends walking from one encounter to the next, or the interruptions that the staff physician could encounter in this walk time.
Recommendations:

The first recommendation is to standardize scheduling procedures for each clinic. In the standardized schedules, the new patient and return visit patients should be staggered.

Another recommendation is to begin each clinic with two new patients and two return visits. The initial encounter of the two new patients and one of the return visit patients should be done by a resident physician or a technician. This leaves the staff physician free to see the other return visit patient on the first encounter of the day instead of waiting for all first encounters to be done by the resident physician and technicians. After the staff physician is done processing the first return visit patient, he or she can move on to the next return visit patient who has already been seen by the resident physician or technician.

Whenever a return visit patient and a new patient are ready to be seen at the same time, throughout the clinic, the return visit patient should be given priority over the new patient. This will get the return visit patient, who has a shorter procedure time, through the clinic faster, and decreases overall patient wait time.

To better distinguish between new and return visit patients, a color coding system on the patient charts should be implemented. With one color to denote new patients and another to denote return visit patients.

Both clinics should develop a list of short and long common procedures for return visit patients. In the standardized schedule, new and return visits are differentiated. A short return visit is scheduled in a return visit slot, while a long return visit is scheduled in a new patient slot. New patients are all scheduled in a new patient slot. The staff physician is responsible for designating whether the return patient should be scheduled as a short return visit or a long return visit on the patient chart.

Very short return visit procedures should be grouped together in one clinic. A very short procedure could be defined as a patient visit that should take up to twenty or thirty minutes. Currently, there is no clinic on Friday afternoon, therefore, the proposed very short procedure clinic could be held then.

The staff physicians must write down the procedures performed during the patient visit to ease the checkout process.

The final recommendation is to make the staff physicians aware of the time spent with the patients during the encounters. Any decrease in encounter time will decrease total patient time in the system, and total wait time, and increase overall office efficiency.
Background and Purpose

Background:

The Eye Plastics and Neuro-Ophthalmology Clinics of the University of Michigan Hospitals located in the Kellogg Eye Center are well known throughout the state of Michigan for their excellent medical care. However, due to their expertise the clinics have an overabundance of patients requesting care which has lead to inefficient clinic operations. The inefficient clinic operation was recognized as a substantial problem by the staff physicians and the administrative staff. Dr. Christine Nelson, the head staff physician for the Eye Plastics clinic, contacted Elizabeth Othman, Senior Clinical Systems Analyst of the Management Systems Department of the University of Michigan Hospitals, to inquire whether or not this problem could be solved. Elizabeth Othman contacted Richard Coffey, Director of Management Systems of the University of Michigan Hospitals and Adjunct assistant Professor, Industrial and Operations Engineering, University of Michigan, Ann Arbor, who in turn contacted student consultants James Armistead II, Brian Burk, David Chan, and Laural Wagner to analyze the situation.

The Eye Plastics and Neuro-Ophthalmology Clinics use the same office space including eight examination rooms, one visual field room, a clerical staff reception/work area, and a patient wait room. These clinics also share the same technicians, clerical staff, and administrative support staff. The fellow working in the Eye Plastics clinic is Dr. Mont Cartwright, M.D. The resident physicians working in the clinic at the time of this report are: for the Eye Plastics clinic, Dr. John Geiser, for the Neuro-Ophthalmology clinic, Dr. Andrew Moyes and Dr. Andrew Pearce. The technicians are Lisa Carry, Cheryl Caudill, and Barbara Michael. The clerical staff members are Mary Joe Ulrich and Tina Beverley, and Latisha Field, a float clerical staff member. The administrative support includes Margaret Pennington, the clinic supervisor.

The Eye Plastics clinic is responsible for plastic surgery of the eye, and other minor procedures. The clinic is staffed by three staff physicians, and the resident physicians who practice at the clinic for varied periods of time. The staff physicians are Dr. Victor Elner, M.D., Ph.D., Dr. Barton Freuh, M.D. and Dr. Christine Nelson, M.D.

The Neuro-Ophthalmology clinic is responsible for eye care regarding a neurological based disorder. The clinic consists of two staff physicians, and the resident physicians who practice at the clinic for varied periods of time. The staff physicians are Dr. Wayne Cornblath, M.D. and Dr. Jonathan Trobe, M.D.
Purpose:

The purpose of this project is to study the problems experienced at the clinic, analyze this problem and develop recommendations which will increase office efficiency and patient satisfaction. The current clinic operation is experiencing high patient visit and wait times, which have led to patient dissatisfaction. The average patient visit takes between two and five hours per visit. This has created frustration among the staff and patients. With our recommendations we hope to increase office efficiency and patient satisfaction.
Approach and Methodology

Approach:

Our general approach was to look at the clinics individually and as a whole. When looking at the separate clinics, we broke down the patient types into different groups. This allowed us to ascertain factual information about the clinic and how it is run.

Interviews were scheduled with each of the four physicians, the clerical staff and the technicians. These interviews were conducted to gain a general knowledge of clinic activities and procedures. These interviews also provided an opportunity to receive opinions on clinic efficiency, and possible suggestions to decrease patient wait times and improve clinic operations. A staff meeting, conducted by Margaret Pennington, was observed, in which problems in each clinic were discussed. These included scheduling problems and doctors wanting more clinic time.

In order to gain an understanding of clinic operations, patient flow was studied. The method used to determine patient flow was a series of interactions with staff physicians and patients. The interactions with the staff physicians consisted of accompanying the physicians throughout their clinic. This included observing the staff physicians during their exams of the patient. The interactions with the patients consisted of following the patients during their office visit giving insight into what patients experience during their visit.

A time study was done to ascertain figures on patient visit times. In order for this study to be done a data collection form, (shown in Appendix A), was developed to follow a patient for the duration of their visit. This form was attached to the patient charts to make it easily accessible for the staff to record the necessary information. The data collected from the time study was manipulated to derive wait times, total visit times, staff physician encounter times, resident physician encounter times, technician encounter times, and procedure times.

After the data was collected and the patient/staff interactions were analyzed, a flow chart was developed to define the patient flow. These flow charts were made to clarify the actual clinic process.

The flow charts and the data collected were then used to create a simulation program using GPSS/H, a simulation programming language, which models the patient flow of the clinic. This simulation program was done to gain an understanding of where bottlenecks occur in the current operating system, to find the optimum integration between new and return patients, and to find the optimum number of technicians.
Methodology:

The first method used was a time study conducted with the clinic staff members filling in the required information. A copy of the form used is shown in Appendix A. The study was done over a two week period, during which data on eighty-five Eye Plastics patients and eighty-six Neuro-Ophthalmology patients was collected.

The data collected consisted of:

- which staff physician clinic was visited
- patient identification stamp
- patient appointment time
- time the patient arrived
- patient check-in/out time
- whether the patient was a new or a revisit

And for each of up to five patient/staff encounters:

- staff member attending
- time the procedure started/ended
- procedures performed

The data collected was, in some areas, insufficient. Some clinics failed to record information vital to the study. This resulted in the elimination of the incomplete data from the total analysis of the data.

The data from the time study sheets was combined into a large Microsoft Excel 3.0 spreadsheet on the Apple Macintosh computers where it could be analyzed more easily. The spreadsheets used, separated between the Eye Plastics and Neuro-Ophthalmology clinics, can be found on the included computer disk for the Apple Macintosh Computer. The data was divided between the Neuro-Ophthalmology and Eye Plastics clinics, divided by staff physician and then further divided into return and new patients within the clinics. The clinics were divided due to the difference in the nature of the procedures carried out in each clinic. The clinics were divided between staff physicians due to the variation of scheduling practices and general differences between the staff physicians. New and return visit patients were divided because new patients take significantly longer per procedure, and, in general, have more encounters with the staff members than returning patients. New and return patients were also divided to distinguish between the average duration of each procedure and visit to determine the best method of scheduling.
Numbers derived from the data include:

- average wait time per patient
- average length of stay per patient
- average procedure time per patient
- average length of procedure per staff member
- probability of which staff member attends per encounter
- probability of which procedure will be performed per staff member per encounter
- probability of a patient going to the next encounter or leaving the clinic

Each segment of data derived was per Eye Plastic or Neuro-Ophthalmology clinic per staff physician clinic per new or revisit. All numbers derived are available on the included computer disk or in charts that follow.

Two flow charts were developed which modeled the patient visits, one for the Neuro-Ophthalmology clinic and one for the Eye Plastics Clinic. These charts were developed from the data collection forms and from observing the patient visits. The flow charts were generated through the use of MacFlow 3.5.3, a flowcharting program for Apple Macintosh computers. Both flow charts are shown in Appendix B. These were used as a foundation for developing a simulation program which modeled the clinics.

The collated data from the time study was put into a simulation program. Other data used were: the number of exam rooms available, number of technicians, number of receptionists, and one staff physician available. The simulation program was executed for a period of one clinic which is four hours in length. The variables consist of the number of technicians, and the mix of new and return patients. The programming language used was GPSS/H, and the program was overseen by Medini Singh, Associate Professor, Industrial and Operations Engineering, The University of Michigan, Ann Arbor. The program source code is shown in Appendix C.

The objective of the simulation program was to compare different types of patient scheduling procedures to decide on an optimum method. The simulation was broken down into six separate programs. For both the Neuro-Ophthalmology and the Eye Plastics Clinics simulations were developed for four hour clinics of: all new patients, all return visit patients, and a mix of new patients and return visit patients. By breaking the simulation down into these separate components, we were able to compare the results of running clinics in these different fashions. The simulation programs themselves were developed using the data collected from the time study sheets. The simulation works as follows.
When patients first arrive at the given clinic they are assigned a patient type, either new or return visit. Based on patient type they proceed through the system based on probabilities. For the patient’s first encounter their service time is based on the probability of who is attending and what procedure is being done. Following the first procedure a certain percentage of patients check-out. The patient’s second encounter works in a similar manner. Their service time is dependent on the probability of who is attending and the probability of a what procedure is being done. Again, after the second encounter, a certain percentage of the patients check-out. The patient’s third, fourth, and fifth encounter work in the same fashion. However, before a patient is able to move in the system, the appropriate resources must be available to that patient. Before the patient checks-in, they must "seize" a receptionist. Before the patient has a history and eye exam they must "seize" an examination room and "seize" a technician or resident. If any of the necessary resources are unavailable the patient waits. Once all the necessary resources are available the patient then proceeds with the given encounter. The simulation continues bringing patients in throughout the clinic day and moving them through in the manner just described.

When running the six different simulations the number of receptionist, technicians, and resident physicians were all varied to determine their impact on clinic efficiency. The simulations results indicate the utilization of the receptionists, technicians, resident physicians, and staff physicians, as well as average total length of stay and average total service time. See Tables 4 & 5.
Current Situation

The current situation of the clinics is one of inefficient operations. These operations result in high patient wait times and low patient satisfaction regarding these wait times. Patient dissatisfaction is often expressed in comments and/or complaints to all staff levels. These complaints make it increasingly difficult for the staff to maintain good patient relations. One cause of this problem seems to be an inadequate scheduling system. Currently there is no standardized method of scheduling patient appointments. Each staff physician has his or her own scheduling method, which in all cases involves sheets with time slots that are given to the clerks to fill in as patients call in for appointments. In some cases the time slots are labeled to be filled by a return visit or new patient, and in others there are no guidelines at all. This creates problems because some procedures take much longer than others. When several appointments are made at the same time in which long procedures are required, a bottleneck occurs in the system. When this happens the entire system is backed up and large wait times occur. These wait times are the primary reason for customer dissatisfaction.

The differentiation of new and return visit patients is important because there is a substantial difference between patient visit times of new and return patients. The new patients in both clinics take much longer to process than the return visit patients. New patients often require more time in procedures, such as visual fields and dilations, than return visit patients. New patients also have not been diagnosed or given their initial basic examination. Therefore, if several new patients are scheduled at once, a bottleneck may be created.
Limitations

Data collected through interviews concerning percentages and times may not be an accurate representation of the actual figures.

Data collected in the time study was more incomplete from some staff physician clinics than in others. Therefore, some of the number averages may be more representative of one staff physician than another. Failure to record data in the time study could also result in the number of certain procedures, such as dilations or visual fields, to be less than what actually occurred. This would make time, such as time to what for the eyes to dilate and time to wait for the visual field room, counted as unnecessary wait time when the time to wait was needed.

The sample size of the time study could provide significant error in the averages and percentages figured. A collection period longer than two weeks would have provided numbers more closely approaching true averages and percentages, but would have been too long for the time allowed for the project.

Some patients take considerably longer or shorter amounts of time than others. While some of the extreme values were "thrown out" when averaging times in the analysis, a number of these could skew the results.

There are certain limiting factors when developing a simulation which must be taken into account. The simulation programs were developed using the data from the time study forms as well as information obtained during interviews with various members of the staff. The limitations of the data from the interviews and the time study sheets were mentioned previously. Specific limitations to the simulation programs are as follows. Utilization results are based solely on patient interaction. No time is allotted in the simulation for time spent interacting with other members of the staff as happens in the actual clinic. The interaction time of the staff during a clinic is an obvious necessity for proper patient care. However, due to the randomness in both the occurrence and length of these interactions they are not included in the simulation programs. For this reason the utilization results will be lower than the true utilization during a clinic. The most obvious example of this is receptionist utilization. Their utilization results are based only on the time they spend checking-in and checking-out the patients, it does not take into account answering phones, etc. In addition to the utilization numbers being affected, patient total length of stay and total wait times will tend to be lower than the values now occurring in the given clinics.
Findings

Interviews:
Interviews were conducted with each of the staff physicians. From these interviews it was found that clinic procedure times could not be decreased because the quality of care to the patient would also decrease.

The clinics are used as a teaching facility to resident physicians. This causes an increase in patient time spent waiting for the staff physician because the resident physician presents patient cases to the staff physician during the clinic. The presentation time cannot decrease without a decrease in the educational level of the resident physicians.

Also, through the interviews with the staff physicians and receptionists it was found that there was no standardized scheduling system for the clinics. Each staff physician scheduled their patients in a different manner. This makes it difficult for the receptionist to schedule appointments and also lends to clinic inefficiency. The current scheduling system is leading to high wait times and patient dissatisfaction.

The receptionists felt that procedures needed to be documented more clearly. The receptionists need to know what procedures the patient experienced during their visit to check them out. When the procedures are not stated on the patient's form, the receptionist must find the staff physician to find out what was done to the patient. This adds time to the total patient visit time and makes the receptionists job more difficult, taking them away from their normal responsibilities.

Observations:
The clinics were first observed by following staff members during clinic activity. When following the staff physicians it seemed that their time was highly utilized. The staff physicians were constantly moving from one waiting patient to the next, leaving little or no free time for the staff physician. Because each patient coming to the clinic must see the staff physician at least once, and time is scarce for the staff physician, the availability of the staff physician is the limiting factor for throughput in each clinic.

Time Study:
After the initial observations of the clinic, a time study was conducted. Through this study it was found that total wait times were excessive. They were found to be almost as long, on an average, as total procedure times. Procedure time being any interaction with a staff member, and wait time being any time a patient spent waiting to see a staff member. Total patient time in the clinic is total procedure time and total wait time combined. In Tables 1 & 2 total procedure time, total wait time, total time, and percent of
time spent waiting are shown for each individual doctor, for new and return patients. Total percent of time spent waiting is represented graphically in Figures 1 & 2.

From the average clinic times in the time study, return patients were found to take significantly less time than new patients for total procedure time, total wait time, and total time in the clinic (see Tables 1 & 2). This was true for each clinic, and each staff physician.

From the time study, some staff physicians were found to take longer than others to interact with the patients. The Neuro-Ophthalmology clinics, on the whole, have a longer average total patient time than the Eye Plastics clinics. This is assumed to be due to the nature of procedures performed in the clinics (refer to Tables 1 & 2).

Table 1: Eye Plastics Average Patient Visit Times

<table>
<thead>
<tr>
<th>Physician (Patient Type)</th>
<th>Total Procedure Time (minutes)</th>
<th>Total Wait Time (minutes)</th>
<th>Total Clinic Time (minutes)</th>
<th>% of Time Spent Waiting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elner (new)</td>
<td>66.75</td>
<td>102.02</td>
<td>168.77</td>
<td>60.45</td>
</tr>
<tr>
<td>Nelson (new)</td>
<td>86.01</td>
<td>82.94</td>
<td>168.95</td>
<td>49.09</td>
</tr>
<tr>
<td>Elner (return)</td>
<td>37.19</td>
<td>81.91</td>
<td>119.10</td>
<td>68.77</td>
</tr>
<tr>
<td>Nelson (return)</td>
<td>38.34</td>
<td>60.04</td>
<td>98.38</td>
<td>61.03</td>
</tr>
</tbody>
</table>

Table 2: Neuro-Ophthalmology Average Patient Visit Times

<table>
<thead>
<tr>
<th>Physician (Patient Type)</th>
<th>Total Procedure Time (minutes)</th>
<th>Total Wait Time (minutes)</th>
<th>Total Clinic Time (minutes)</th>
<th>% of Time Spent Waiting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornblath (new)</td>
<td>88.24</td>
<td>88.79</td>
<td>175.00</td>
<td>50.73</td>
</tr>
<tr>
<td>Trobe (new)</td>
<td>90.12</td>
<td>104.36</td>
<td>194.48</td>
<td>53.66</td>
</tr>
<tr>
<td>Cornblath (return)</td>
<td>47.67</td>
<td>46.52</td>
<td>104.19</td>
<td>45.03</td>
</tr>
<tr>
<td>Trobe (return)</td>
<td>39.52</td>
<td>89.01</td>
<td>128.53</td>
<td>69.24</td>
</tr>
</tbody>
</table>
Eye Plastics Percentage of Total Patient Waiting Time

![Bar chart showing percentage of total patient waiting time for Eye Plastics by staff physicians. Elner (new) has 60.45%, Nelson (new) has 49.09%, Elner (return) has 68.77%, and Nelson (return) has 61.03%.

Figure 1

Neuro-Ophthalmology Percentage of Total Patient Waiting Time

![Bar chart showing percentage of total patient waiting time for Neuro-Ophthalmology by staff physicians. Cornblath (new) has 50.73%, Trobe (new) has 53.66%, Cornblath (return) has 45.03%, and Trobe (return) has 69.24%.

Figure 2
The time study also showed the percentage of patients that required a specific number of procedures (see Figures 3 & 4). It is assumed that the greater the number of procedures a patient receives, the greater is the amount of time that each patient spends in the clinic.

**Eye Plastics Percentage of Patients Per Encounter**

![Bar chart showing the percentage of patients per encounter for new and return cases. The chart indicates a decrease in the percentage of new patients as the number of encounters increases, while the number of return patients decreases.](chart)

*Figure 3*
Neuro-Ophthalmology Percentage of Patients Per Encounter

![Bar Chart: Neuro-Ophthalmology Percentage of Patients Per Encounter](chart.png)

**Figure 4**
The percent utilization from the time study of each staff physician showed that staff physician utilization is not as high as it appeared when following the staff physicians through the clinic. A large portion of the unutilized time is due to the fact that when the clinic starts, the staff physician, in general, does not see a patient in the first encounter. The staff physician generally waits until after the first patient is done with their first encounter to start work in the clinic. In other words, the staff physician does not start work when the clinic starts. The first staff member to see the patient is usually either a resident physician, or a technician. An encounter is when the patient is seen by any staff member other than the receptionists. The utilization breakdown per staff physician can be seen in Table 3.

The time study also does not take into account time the staff physician spends walking from one encounter to the next, or the interruptions that the staff physician could encounter in this walk time.
### Table 3: Staff Physician Time Utilization

<table>
<thead>
<tr>
<th>Staff Physician</th>
<th>Clinic Utilization (%)</th>
<th>Actual Utilization (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neuro-Ophthalmology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cornblath</td>
<td>76.89</td>
<td>84.30</td>
</tr>
<tr>
<td>Trobe</td>
<td>41.67</td>
<td>62.50</td>
</tr>
<tr>
<td><strong>Eye Plastics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elner</td>
<td>62.14</td>
<td>84.76</td>
</tr>
<tr>
<td>Nelson</td>
<td>55.59</td>
<td>73.29</td>
</tr>
</tbody>
</table>

**Definitions for Table 3:**

Clinic Utilization = \[ \frac{\sum TE}{\sum (END - APP)} \]

- **TE** = total time of encounters by the staff physician during one clinic
- **END** = End time of last staff physician/patient encounter of the clinic
- **APP** = First scheduled appointment time of the clinic
- \( \sum \) denotes sum of

Actual Utilization = \[ \frac{\sum TE}{\sum (END - FE)} \]

- **TE** = total time of encounters by the staff physician during one clinic
- **END** = End time of last staff physician/patient encounter of the clinic
- **FE** = Start time of first staff physician/patient encounter of the clinic
- \( \sum \) denotes sum of
Staff Physician Time Utilization

<table>
<thead>
<tr>
<th>Staff Physician</th>
<th>Clinic % Utilization</th>
<th>Actual % Utilization</th>
</tr>
</thead>
<tbody>
<tr>
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<td>84.30</td>
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<td>Trobe</td>
<td>41.67</td>
<td></td>
</tr>
<tr>
<td>Elnor</td>
<td>62.50</td>
<td></td>
</tr>
<tr>
<td>Nelson</td>
<td>55.99</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5
Flow Charts:
The flow charts, contained in Appendix B, depict the flow in the clinics. The flow charts were developed from findings in the interviews, observations, and time study. It is important to note that there is no specific flow pattern in either clinic. In other words, each patient is unique in the procedures they require.

Simulation:
The findings from the simulation programs are based on simulation runs using two receptionists, two technicians, and two resident physicians. Figures 6 and 7 analyze the effect of increasing the clinic staff from two to three technicians. In Figure 6, relating to the Eye Plastics clinic, the results indicate that the increase in technicians does have a significant effect on patient total length of stay. In contrast, Figure 7, relating to Neuro-Ophthalmology Clinic, the results do not indicate significant improvements in patient length of stay due to the increased number of technicians. These results are consistent with the over-all study findings that Neuro-Ophthalmology has lower utilization of technicians due to the nature of the procedures performed. See Tables 4 and 5. Due to the limitations of the simulation previously discussed, staffing decisions should not be made based on simulation results.
Figure 6

Eye Plastics Simulation
2 Technicians vs. 3 Technicians
Effect on Length of Stay

<table>
<thead>
<tr>
<th>Simulation Type</th>
<th>Average Length of Stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Technicians (Black)</td>
<td>200</td>
</tr>
<tr>
<td>3 Technicians (White)</td>
<td>200</td>
</tr>
<tr>
<td>Combined</td>
<td>200</td>
</tr>
</tbody>
</table>

New Patient
Return Visit

Figure 6
Neuro-Ophthalmology
2 Technicians vs. 3 Technicians
Effect on Length of Stay

Figure 7
Table 4: Eye Plastics Simulation  
Staff Member Utilization

<table>
<thead>
<tr>
<th>Staff Member</th>
<th>New Patient</th>
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<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptionist</td>
<td>13.64</td>
<td>16.36</td>
<td>14.07</td>
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<tr>
<td>Technician</td>
<td>81.98</td>
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<td>41.11</td>
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<tr>
<td>Resident Physician</td>
<td>33.17</td>
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<td>25.09</td>
</tr>
<tr>
<td>Staff Physician</td>
<td>52.13</td>
<td>82.50</td>
<td>91.10</td>
</tr>
</tbody>
</table>

Table 5: Neuro-Ophthalmology Simulation  
Staff Member Utilization

<table>
<thead>
<tr>
<th>Staff Member</th>
<th>New Patient</th>
<th>Return Visit</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptionist</td>
<td>12.05</td>
<td>14.24</td>
<td>12.80</td>
</tr>
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<td>Technician</td>
<td>60.60</td>
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<tr>
<td>Resident Physician</td>
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<td>Staff Physician</td>
<td>66.51</td>
<td>73.89</td>
<td>68.72</td>
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</table>

The results presented in Tables 6 and 7 help conclude that a mix of new patients and return visits within a given clinic is the most efficient scheduling method. Several key factors must be pointed out when analyzing the results of the simulations. The first conclusions is that an all return visit clinic gives the best results. This is consistent with the time study data. The reason an all return visit clinic works the best is because return visit patients generally require less total service time than new patients. The percentage wait time of the return visits is almost equal to that of the new patients, but their total length of stay is substantially less. Figure 8 from the time study data as well as Figures 9 and 10 from the simulation, seen below, support this conclusion. The result of the lower required service time is a more efficient clinic. The problem with running an all return visit clinic is that it requires the running of an all new patient clinic.
Table 6: Eye Plastics Simulation
Average Patient Visit Times

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Total Procedure Time (minutes)</th>
<th>Total Wait Time (minutes)</th>
<th>Total Clinic Time (minutes)</th>
<th>% of Time Spent Waiting</th>
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</thead>
<tbody>
<tr>
<td>New Patient</td>
<td>77.81</td>
<td>84.77</td>
<td>162.58</td>
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<tr>
<td>Return Visit</td>
<td>48.20</td>
<td>39.39</td>
<td>87.59</td>
<td>44.97</td>
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<tr>
<td>Combined</td>
<td>59.544</td>
<td>65.92</td>
<td>125.46</td>
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</table>

Table 7: Neuro-Ophthalmology Simulation
Average Patient Visit Times

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Total Procedure Time (minutes)</th>
<th>Total Wait Time (minutes)</th>
<th>Total Clinic Time (minutes)</th>
<th>% of Time Spent Waiting</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Patient</td>
<td>92.14</td>
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<td>Return Visit</td>
<td>49.28</td>
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<tr>
<td>Combined</td>
<td>70.06</td>
<td>41.17</td>
<td>111.23</td>
<td>37.01</td>
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</tbody>
</table>
Average Total Patient Time
Service Time vs. Wait Time

Figure 8
Eye Plastics Simulation
Total Length of Stay vs. Total Service Time

New Patient

Return Visit

Combined

Simulation Type

Figure 9
Neuro-Ophthalmology
Total Length of Stay vs. Total Service Time

Figure 10
The all new patient clinic for both Neuro-Ophthalmology and Eye Plastics is a bad idea. Looking at the average total service time for new patients in both clinics helps explain the problem. The average Neuro-Ophthalmology new patient requires 88.94 minutes of service time, while the average Eye Plastics new patient requires 80.24 minutes of service time (results from time study, see Figures 11 and 12). With this much average total service time bottlenecks and excessive wait times are inevitable when trying to run an all new patient clinic. By combining the two patient types within a clinic, it will serve two purposes. The first purpose is to mitigate the effect of running an all new patient clinic. The lower total required service time for the return visit patients will help break up the bottlenecks created by the new patients. The second purpose is to better utilize the support staff. The two different patient types have different required services. As a result technicians and resident physician utilization varies from clinic to clinic. By combining the two patient types within a clinic the technicians will have less visual fields to perform than in an all new patient clinic and can thus concentrate on the longer first encounters.
Eye Plastics
Service Time vs. Wait Time
New Patient

Figure 11

Average Total Wait Time
70.20 Minutes

Average Total Service Time
80.24 Minutes
Figure 12

Neuro-Ophthalmology
Service Time vs. Wait Time
New Patient

Average Total Wait Time
94.31 Minutes

Average Total Service Time
88.94 Minutes
A situation which often occurs because of the shared space of the two
different clinics is an overlap of the morning and afternoon clinics. When a
morning clinic runs over their given time they are often still operating while
an afternoon clinic is trying to start. This situation was simulated for a two
hour period with an Eye Plastics Clinic overlapping into a Neuro-
Ophthalmology Clinic. Simulations were run for the current situation with
eight examination rooms and a situation with only four examination rooms.
The results are presented below in Figure 13.
During the two-hour overlap period with eight examination rooms, the Eye
Plastics Clinic experienced a 5.70% increase over "normal" in patient total
length of stay, while the Neuro-Ophthalmology Clinic experienced a 4.67% increase over "normal" in patient total length of stay. When reducing the
number of examination rooms to four the Eye Plastics Clinic experienced a
23.33% increase over "normal" in patient total length of stay, while the
Neuro-Ophthalmology Clinic experienced a 28.85% increase over "normal"
in patient total length of stay.
Clinic Overlap Compared to "Normal"
8 Exam Rooms vs. 4 Exam Rooms

Figure 13
Additional Graphical Analysis
Eye Plastics
Service Time vs. Wait Time
Return Visit

Average Total Wait Time
61.71 Minutes

Average Total Service Time
37.76 Minutes
Neuro-Ophthalmology
Service Time vs. Wait Time
Return Visit

Average Total Wait Time
57.83 Minutes

Average Total Service Time
43.38 Minutes
Eye Plastics Clinic
New Patient vs. Return Visit
Procedure Times

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<th>Procedure</th>
<th>New Patient (black)</th>
<th>Return Visit (grey)</th>
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<tr>
<td>Check-In</td>
<td>5</td>
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<td>History/Eye Exam</td>
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<tr>
<td>Check-Out</td>
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</tbody>
</table>
Neuro-Ophthalmology
New Patient vs. Return Visit Procedure Times

New Patient (black)
Return Visit (grey)
New Patient Time vs. Return Visit Time
Average of Total Clinic Time Per Clinic

- Eye Plastics: New 150.44, Return Visit 99.47
- Neuro-Ophthalmology: New 183.25, Return Visit 101.21
New Patient Visit Times vs. Return Visit Patient Visit Times
Per Staff Physician

[Bar chart showing comparison of new patient visit times and return visit patient visit times per staff physician.]

- Elner: New 168.77, Return 119.10
- Nelson: New 168.95, Return 98.38
- Cornblath: New 177.03, Return 94.19
- Trobe: New 194.48, Return 128.53

University of Michigan Medical Center
Management Systems
Eye Plastics Average Patient Visit Times (in Minutes)

![Graph showing average patient visit times for different staff physicians and patient types. The graph includes bars for total wait time and total procedure time.]
Neuro-Ophthalmology Average Patient Visit Times (in Minutes)

Staff Physician

- Cornblath (new)
- Trobe (new)
- Cornblath (return)
- Trobe (return)

- Total Wait Time
- Total Procedure Time
Conclusions and Recommendations

The first recommendation is to standardize scheduling procedures for each clinic. In the standardized schedules, the new patient and return visits should be staggered. This is true because the procedures that new patients require take longer than return visit procedures, causing new patients to spend a longer amount of time in the clinic. When too many new patients are in the clinic at one time, a backlog of patients is created, causing patients to wait longer. By blending return visits and new patients, this problem will be lessened. A sample schedule can be seen on the following page.

Another recommendation is to begin each clinic with two new patients and two return visits. The first encounter a patient has generally consists of a history/eye exam. The history/eye exam of the new patients is usually much longer and more in depth than the return visit history/eye exam. The history/eye exam of the two new patients and one of the return visit patients should be done by a resident physician or a technician. This leaves the staff physician free to see the other return visit patient on the first encounter of the day instead of waiting for all first encounters to be done by the resident physician and technicians. This will increase staff physician utilization and get the initial return patient in and out of the system faster, increasing throughput by one patient per clinic. The other return visit scheduled at the beginning of the clinic can be seen by a resident physician or technician for the initial encounter. Therefore, after the staff physician is done processing the first return visit patient, he or she can move on to the next return visit patient who has already been seen by the resident physician or technician. This change in the schedule would make the staff physician utilization more closely resemble the actual utilization in Table 3.

Whenever a return visit patient and a new patient are ready to be seen at the same time, throughout the clinic, the return visit patient should be given priority over the new patient. This will get the return visit patient, who has a shorter procedure time, through the clinic faster, and decreases overall patient wait time.

To better distinguish between new and return visit patients on the patient charts, a color coding system should be implemented. This could be done by using, for example, blue stickers on the charts to denote new patients and red stickers on the charts to denote return visit patients.
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<th>Return Patient Information</th>
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Neuro-Ophthalmology
Morning Clinic:

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Neuro-Ophthalmology  
Afternoon Clinic:

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**Friday Afternoon**

**Short Procedure Clinic:**

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</table>
Both clinics should develop a list of short and long common procedures for return visit patients. In the standardized schedule, new and return visits are differentiated. A short return visit is scheduled in a return visit slot, while a long return visit is scheduled in a new patient slot. New patients are all scheduled in a new patient slot. Long return visit patients are scheduled in the new patient slot and not the return patient slot because too many long procedures scheduled will create a bottleneck. The staff physician is responsible for designating whether the return patient should be scheduled as a short return visit or a long return visit on the patient chart. If a differentiation between long return visit and new patients needs to be made on the schedule, a mark such as an "L" can be put next to the return visit. This will avoid confusion over whether the patient is a new patient or a long return visit. The recommended scheduling sheet does not leave slots for patients that are added on to the schedule due to the fact that, on the average, the number of add-ons is equal to the number of cancellations. Therefore, there should be slots available to add-on patients.

Very short return visit procedures should be grouped together in one clinic. A very short procedure could be defined as a patient visit that should take up to twenty or thirty minutes. This will allow many patients to go through the clinic without having to wait a long amount of time. If these very short procedure patients are scheduled on regular days, they are subjected to the same waiting time as patients requiring longer procedures. Currently, there is no clinic on Friday afternoon, therefore, the proposed very short procedure clinic could be held then. The Friday afternoon clinic, being at an unpopular time, could be rotated between and/or shared by the staff physicians. By limiting the Friday afternoon clinic to short procedures, this will insure that the clinic will not run over by excessive amounts of time.

The staff physicians must write down the procedures performed during the patient visit to ease the checkout process. When this is not done, it causes the clerical staff to leave their assigned duties to find out what procedures were performed. Besides disrupting the clerical staff, it also disrupts the staff physician, the resident physicians, or the technicians when they must be asked, after the fact, what procedures were performed on the patient.

The final recommendation is to make the staff physicians aware of the time spent with the patients during the encounters. Any decrease in encounter time will decrease total patient time in the system, and total wait time, and increase office efficiency.

In closing, the recommendations described above, using a standardized schedule, beginning each clinic with two new patients and two return visits, giving return visit patients priority over new patients, developing a list of
short and long common procedures for return visit patients, using a color coding system to differentiate between new and return visit patients, having very short return visit procedures grouped together in one clinic, having the staff physicians write down the procedures performed, and making the staff physicians aware of the time spent with the patients during the encounters, if implemented will help to improve clinic operations. The environment in the clinic will be more relaxed between patient and staff, the total time in the clinic per patient will decrease on the whole, and throughput should be increased.
Appendices
<table>
<thead>
<tr>
<th>Encounter</th>
<th>Doctor</th>
<th>Resident</th>
<th>Technician</th>
<th>Start Time</th>
<th>End Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
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<td>5th</td>
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</tr>
</tbody>
</table>

Other task: ____________________________
Neuro-Ophthalmology Clinic

Enter Clinic

Receptionist Available?
- No → Wait
- Yes → Check In

Check In

Room Available?
- No → Wait
- Yes → Staff Member Available?

Staff Member Available?
- No → Wait
- Yes → Technician Available?

Technician Available?
- Yes → Go Into Room
- No → Resident Available?

Resident Available?
- Yes → Go Into Room
- No → Staff Physician Available?

Staff Physician Available?
- No
- Yes
SIMULATE

EYE PLASTICS - COMBINED SIMULATION

COMPILER DIRECTIVES

TECH EQU 1,S
RES EQU 2,S
STAFF EQU 3,S

INTEGER &TIME, &TEKS, &RED, &RECPT, &DAYS
REAL &TTECH, &TSTAFF, &TSERVICE, &TSYSTEM, &TRECPT, &TRES

CONTROL STATEMENTS

WTECH1 FUNCTION RN3,E3 First
encounter is with technician
.700,16+(24*FRN4)/.850,9/1.6+(10*FRN4) Advance
based on procedure.

WRES1 FUNCTION RN5,E2 First
encounter is with resident
.750,20+(12*FRN6)/1.15+(8*FRN6)

ENCOUNT1 FUNCTION RN9,D2 Function to
decide who brings patient
.930,1/1.0,2 in for first
encounter.

WTECH2 FUNCTION RN11,E2 Second
encounter is w/ tech
.50,32+(16*FRN7)/1,4+(4*FRN7) Adv based on
procedure

WRES2 FUNCTION RN13,E3 Second enctr
is w/ res
.520,11+(20*FRN8)/.550,2+(FRN8)
procedure.
1,10+(10*FRN8)

2nd encotr

Adv based on

WSTAFF2 FUNCTION RN15,E2
is w/ staff physician
.070,12+(10*FRN16)/1,8+(5*FRN16)

WSTAFF3 FUNCTION RN15,E2
w/ staff physician
.170,5+(8*FRN16)/1,8+(8*FRN16)

3rd encotr is
Adv based on

ENCOUNT2 FUNCTION RN9,D3
decide who patient sees
.004,1/.690,2/1.0,3

3rd encotr is
Adv based on

ENCOUNT3 FUNCTION RN9,D3
decide who 3rd encounter
.030,1/.110,2/1.0,3

3rd encotr is
Adv based on

ENCOUNT4 FUNCTION RN9,D1
w/ staff physician
1.0,3

4th encotr is
Adv based on

ENCOUNT5 FUNCTION RN15,E1
w/ staff physician
1.8+(8*FRN26)

5th encotr is
Adv based on

WSTAFF4 FUNCTION RN15,E2
w/ staff physician
.830,8+(8*FRN16)/1,5+(8*FRN16)

WSTAFF5 FUNCTION RN15,E1
w/ staff physician
1.8+(8*FRN26)

DILATE FUNCTION RN20,E2
decide which patients
.88,0/1,20+(10*FRN21)
dilation and advance time.

Fnctn. to

ENCOUNT2 FUNCTION RN9,D3
Fnctn. to
decide who patient sees
.004,1/.690,2/1.0,3

Receive

ENCOUNT3 FUNCTION RN9,D3
will be with.

WTECH3 FUNCTION RN3,E1
w/ tech
1,7+(6*FRN22)
proc.

WRES3 FUNCTION RN13,E2
w/ res
.330,15+(10*FRN14)/1,10+(9*FRN14)
proc.

3rd encotr is
Adv based on

WSTAFF3 FUNCTION RN15,E2
w/ staff physician
.170,5+(8*FRN16)/1,8+(8*FRN16)
proc.

WTECH3 FUNCTION RN3,E1
w/ tech
1,7+(6*FRN22)
proc.

ENCOUNT3 FUNCTION RN9,D3
decide who 3rd encounter
.030,1/.110,2/1.0,3

WSTAFF4 FUNCTION RN15,E2
w/ staff physician
.830,8+(8*FRN16)/1,5+(8*FRN16)
proc.

ENCOUNT4 FUNCTION RN9,D1
w/ staff physician
1.0,3

ENCOUNT5 FUNCTION RN15,E1
w/ staff physician
1.8+(8*FRN26)
proc.
ENCOUNT5 FUNCTION RN9,D1 5th encnt is
w/ staff physician 1.0,3

*****************************************************************
*
*****************************************************************
*
NWTECH1 FUNCTION RN3,E3 First
encounter is with technician
.670,18+(8*FRN4)/.910,17+(6*FRN4)
1.0,18+(10*FRN4) Advance based
on procedure.

NWRES1 FUNCTION RN5,E2 First
encounter is with resident
.500,20+(12*FRN6)/1.0,20+(10*FRN6)
based on procedure.

NENCNT1 FUNCTION RN8,D2 Function to
decide who brings patient
.84,1/1.0,2 in for first
encounter.

NWTECH2 FUNCTION RN9,E1 Second
encounter is w/ tech 1.0,18+(10*FRN7)
procedure

NWRES2 FUNCTION RN10,E3 Second
encnt is w/ res
.500,21+(9*FRN11)/.580,8+(6*FRN11)
1.0,21+(8*FRN11) Adv based on
procedure.

NWSTAFF2 FUNCTION RN15,E3 2nd encnt
is w/ staff physician
.110,22+(7*FRN12)/.330,16+(6*FRN12)
1.0,15+(9*FRN12) Adv based
on procedure.

NENCNT2 FUNCTION RN13,D3 Fnctn. to
decide who patient sees
.050,1/.600,2/1.0,3 on 2nd encnt.

NDILATE FUNCTION RN14,E2 Fnctn. to
decide which patients
.05, 0/1, 20+(10*FRN15) dilation and advance time
Receive

NWTECH3 FUNCTION RN16, E1
is w/ tech
1.0, 15+(12*FRN17)
base on proc.

NWRES3 FUNCTION RN19, E1
w/ res
1.0, 17+(14*FRN18)
on proc.

NWSTAFF3 FUNCTION RN20, E2
is w/ staff physician
.080, 12+(14*FRN21)/1.0, 13+(11*FRN21)
on proc.

NENCNT3 FUNCTION RN9, D3
decide who 3rd encounter
.180, 1/.300, 2/1.0, 3

NWRES4 FUNCTION RN24, E1
1.0, 1C+(24*FRN25)

NWSTAFF4 FUNCTION RN26, E1
w/ staff physician
1, 13+(12*FRN27)
proc.

NENCNT4 FUNCTION RN28, D2
is w/ staff physician
.400, 2/1.0, 3

NWSTAFF5 FUNCTION RN30, E1
w/ staff physician
1, 11+(18*FRN29)
on proc.

NENCNT5 FUNCTION RN9, D1
w/ staff physician
1.0, 2

ROOM STORAGE 8
storages
VFROOM STORAGE 1
""
STAFF STORAGE 1
""
PROGRAM BEGINS

Generate stream of patients after four hours

Test LE 240,AC1,PROCESS No patients after four hours

Terminate 0 Death to XACT!!

Generate initial patients

Process Transfer .350,,NPROCESS Reception
Queue SYSTEM
Queue RECEPT
Enter RECEPT
Depart RECEPT
Advance 1+4*FRN7

Time
Leave RECEPT

Encount1 Assign 1,FN(Encount1),PL Call fnctn for 1st encotr attendee

Enter PL1
Test E PL1,1,T1RES Test to see if w/ tech

Advance FN(Wtech1)
Leave PL1
Transfer ,Encount2 Transfer to enctr 2

T1RES Advance FN(Wres1)
Leave PL1

Encount2 Transfer .172,,CHECKOUT Prob of only 1 encotr.

Assign 2,FN(Encount2),PL Call fnctn for 2nd encotr.

Enter PL2
Test E PL2,1,T2RES Test for w/ tech

Advance FN(Wtech2)
Leave PL2
Advance FN(Dilate)
TRANSFER\nTEST E \nADVANCE \nLEAVE \nADVANCE \nTRANSFER \nADVANCE \nLEAVE \nADVANCE \nTRANSFER \nASSIGN \nENTER \nTEST E \nADVANCE \nLEAVE \nADVANCE \nTRANSFER \nASSIGN \nENTER \nADVANCE \nLEAVE \nTRANSFER \nASSIGN \nENTER \nTEST NE \nTEST G \nTEST NE \nTEST G \nTRANSFER \nGETSTAFF ENTER

Test for w/
See staff by
Prob of only
Call fnctn
ADVANCE 3+(18*FRN35)
LEAVE STAFF

PAY ENTER RECEPT Patient
checks out
ADVANCE 1+6*FRN8
LEAVE RECEPT

leaves system

TERMINATE 0

***************************************************************
*************
***************************************************************
*************

PROCESS QUEUE SYSTEM
QUEUE RECEPT
ENTER RECEPT
DEPART RECEPT
ADVANCE 1+4*FRN7 Reception
time

LEAVE RECEPT

 sharks Assign 1, FN(NENCNT1), PL 1st enctr attendee
ENTER PL1
TEST E PL1, 1, T1RES Test to see
if w/ tech
ADVANCE FN(NWTECH1)
LEAVE PL1
TRANSFER , NENCNT2 Transfer to

T1RES ADVANCE FN(NWRES1)
LEAVE PL1

NENCNT2 TRANSFER .120,, NCHECK

assign 2, FN(NENCNT2), PL 2nd enctr.
ENTER PL2
TEST E PL2, 1, T2RES Test for w/
tech
ADVANCE FN(NWTECH2)
LEAVE PL2
ADVANCE FN(NDILATE)
TRANSFER , NENCNT3

T2RES TEST E PL2, 2, T2STAFF Test for w/
ADVANCE FN(NWRES2)
LEAVE PL2
ADVANCE FN(NDILATE)
TRANSFER ,NENCNT3
T2STAFF ADVANCE FN(NWSTAFF2)
by default
LEAVE PL2
ADVANCE FN(NDILATE)
point in procedure
TRANSFER,NENCNT3

NENCNT3 TRANSFER .228,,NCHECK

T3STAFFADVANCEFN(NWSTAFF3)

ASSIGN 3,FN(NENCNT3),PL

Call fnctn
for 3rd encnt

ENTER PL3
TEST E PL3,1,T3RES
ADVANCE FN(NWTECH3)
LEAVE PL3
TRANSFER ,NENCNT4
T3RES TEST E PL3,2,T3STAFF
ADVANCE FN(NWRES3)
LEAVE PL3
TRANSFER ,NENCNT4
T3STAFF ADVANCE FN(NWSTAFF3)
LEAVE PL3

NENCNT4 TRANSFER .606,,NCHECK

ASSIGN 4,FN(NENCNT4),PL

ENTER PL4
TEST E PL4,1,T4RES
LEAVE PL4
TRANSFER ,NENCNT5
T4RES TEST E PL4,2,T4STAFF
ADVANCE FN(NWRES4)
LEAVE PL4
TRANSFER ,NENCNT5
T4STAFF ADVANCE FN(NWSTAFF4)
LEAVE PL4

NENCNT5 TRANSFER .600,,NCHECK

ASSIGN 5,FN(NENCNT5),PL

ENTER PL5
ADVANCE FN(NWSTAFF5)
LEAVE PL5

NCHECK TEST NE PL2,3,OUT
TEST NE PL3,3,OUT
TEST G PL3,0,SEESTAFF
TEST NE PL4,3,OUT
TEST G PL4,0,SEESTAFF
Welcome to the eye clinic simulation program. This is an interactive program. You will be asked to input data regarding the number of technicians, residents, and receptionists this model will simulate.

Please type in the data requested without spaces and hit "ENTER" after each request. The number of people should be greater than 0 and less than 6.
1Please type in the number of technicians on duty:

GETLIST ERR=BADDAT1,(&TEKS) Error safety

PUTPIC LINES=2

1Please type in the number of residents on duty:

GETLIST ERR=BADDAT1,(&RED)

PUTPIC LINES=2

1Please type in the number of receptionists on duty:

GETLIST ERR=BADDAT1,(&RECP)

PUTPIC LINES=2

1Please type in the number of 4 hour clinics you would like to simulate:

GETLIST ERR=BADDAT1,(&DAYS)

IF

(&TEKS>5) OR (&RED>5) OR (&RECP>5) OR (&TEKS<1) OR
(&RED<1) OR (&RECP<1) OR (&DAYS<1) Tests for valid data entry

GOTO BADDAT1

ENDIF

TECH STORAGE &TEKS Variable storage assignment
RES STORAGE &RED
RECEPT STORAGE &RECP
GOTO LAST Skips error line if no error present

BADDAT1 PUTPIC LINES=2 Error message

The information you have entered is incorrect.
Please re-enter the data.

GOTO TES

LAST PUTPIC LINES=1

The simulation will begin now. Thank you for your input.

DO &TIME=1,&DAYS Data compilation section

START 1, NP
LET &TRES=&TRES+SR(RES)
LET &TTECH=&TTECH+SR(TECH)
LET &TSTAFF=&TSTAFF+SR(STAFF)
LET &TRECP=&TRECP+SR(RECEPT)
LET &TSYSTEM=&TSYSTEM+QT(SYSTEM)
LET 
&TSERVICE=&TSERVICE+(ST(TECH)+ST(RES)+ST(STAFF)+ST(RECEPT))
CLEAR 
ENDDO
PUTPIC 
LINES=6,FILE=SYSPRINT,(&DAYS,(&TRECPT/&DAYS*.1),(&TTECH/&DAYS*.1),(&TRES/&DAYS*.1),(&TSTAFF/&DAYS*.1))

The following results are averages of the *day(s).
The percentage utilization of the following entities are:
  Receptionists **,**
  Technicians **,**
  Resident Physician **,**
  Staff Physician **,**

PUTPIC 
LINES=2,FILE=SYSPRINT,((&TSYSTEM/&DAYS),(&TSERVICE/&DAYS))
The average length of stay in the clinic was ***.*** minutes.
The average total service time was ***.*** minutes.
END
**NEURO-OPTHALMOLOGY COMBINED SIMULATION**

**COMPILER DIRECTIVES**

**CONTROL STATEMENTS**

```plaintext
TECH EQU 1,S
RES EQU 2,S
STAFF EQU 3,S

INTEGER &TIME,&TEKS,&RED,&RECPT,&DAYS
REAL &TTECH,&TSTAFF,&TSERVICE,&TSYSTEM,&TRECPT,&TRES

WTECH1 FUNCTION RN3,E3
 encounter is with technician
 .200,13+(24*FRN4)/.400,6/1,3+(1O*FRN4)
 based on procedure.

WRES1 FUNCTION RN5,E5
 encounter is with resident
 .684,21+(12*FRN6)/.737,10+(26*FRN6)
 based on procedure.
 .790,1+(4*FRN6)/.895,22/1,17

ENCOUNT1 FUNCTION RN9,D2
 decide who brings patient
 .345,1/1.0,2
 encounter.

WTECH2 FUNCTION RN11,D1
 encounter is w/ tech 1,10
 procedure
```

First
Advance
First
Advance
Function to
in for first
Second
Adv based on
WRES2 FUNCTION RN13,E1
is w/ res
1,10+(26*FRN14)
on procedure.

WSTAFF2 FUNCTION RN15,E6
is w/ staff physician
.083,15+(20*FRN16)/.416,6+(12*FRN16)
.499,1+(4*FRN16)/.624,4+(6*FRN16)
.707,1+(20*FRN16)/1,3+(24*FRN16)

ENCOUNT2 FUNCTION RN9,D3
decide who patient sees
.037,1/.111,2/1.0,3

DILATE FUNCTION RN20,E2
decide which patients
.78,0/1,20+(10*FRN21)
dilation and advance time.

WTECH3 FUNCTION RN3,E1
w/ tech
1,27+(12*FRN4)
on proc.

WRES3 FUNCTION RN13,E1
w/ res
1,7+(24*FRN14)
on proc.

WSTAFF3 FUNCTION RN15,E4
w/ staff physician
.167,15+(20*FRN16)/.500,4+(6*FRN16)
on proc.
.833,3+(24*FRN16)/1,1+(20*FRN16)

ENCOUNT3 FUNCTION RN9,D3
decide who 3rd encounter
.200,1/.410,2/1.0,3

WSTAFF4 FUNCTION RN15,E3
w/ staff physician
.333,6+(12*FRN16)/.666,1+(20*FRN16)
1,4+(6*FRN16)

ENCOUNT4 FUNCTION RN9,D1
w/ staff physician
1.0,3
WSTAFF5 FUNCTION RN15,E1
w/ staff physician
1.0,6+(12*FRN16)
on proc.

ENCOUNT5 FUNCTION RN9,D1
w/ staff physician
1.0,3

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NWTECH1 FUNCTION RN3,E3
First encounter is with technician
.870,29+(32*FRN4)/.940,13+(24*FRN4)
1.0,36+(12*FRN4)
Advance based on procedure.

NWRES1 FUNCTION RN5,E4
First encounter is with resident
.760,39+(26*FRN6)/.820,7+(24*FRN6)
based on procedure.
.940,1.0+(3*FRN6)/1.0,9+(10*FRN6)

NENCNT1 FUNCTION RN8,D2
Function to decide who brings patient
.47,1/1.0,2
encounter.

NWTECH2 FUNCTION RN9,E3
Second encounter is w/ tech
.17,1.0+(3*FRN7)/.840,36+(12*FRN7)
1.0,28+(14*FRN7)
on procedure

NWRES2 FUNCTION RN10,E3
Second encounter is w/ res
.33,35+(6*FRN11)/.66,13+(12*FRN11)
1.0,1+(3*FRN11)
on procedure.

NWSTAFF2 FUNCTION RN15,E5
2nd enctr is w/ staff physician
an
.09,15+(20*FRN12)/.310,6+(12*FRN12)
.830,5+(2*FRN12)
on procedure.
.950,3+(18*FRN12)/1.0,6+(12*FRN12)
NENCNT2 FUNCTION RN13,D3

declare who patient sees

.1875,1/.28125,2/1.0,3

encntr.

NDILATE FUNCTION RN14,E2

declare which patients receive dilation and advance time

.22,0/1,20+(10*FRN15)

NWTECH3 FUNCTION RN16,E2

is w/ tech

.33,28+(14*FRN17)/1.0,8+(11*FRN17)

Adv based on proc.

NWRES3 FUNCTION RN19,E2

w/ res

.40,1+(4*FRN18)/1.0,9+(10*FRN18)

Adv based on proc.

NWSTAFF3 FUNCTION RN20,E6

is w/ staff physician

.18,15+(20*FRN21)/.24,6+(12*FRN21)

Adv based on proc.

.42,10+(6*FRN21)/.48,5+(2*FRN21)

.83,6+(12*FRN21)/1.0,3+(18*FRN21)

NENCNT3 FUNCTION RN9,D3

declare who 3rd encounter will be with.

.125,1/.333,2/1.0,3

NWTECH4 FUNCTION RN22,E1

1.0,27+(12*FRN23)

NWRES4 FUNCTION RN24,E1

1.0,7+(24*FRN25)

NWSTAFF4 FUNCTION RN26,E5

w/ staff physician

.13,15+(20*FRN27)/.38,6+(12*FRN27)

.63,3+(18*FRN27)/.76,5+(2*FRN27)

1,6+(12*FRN27)

Adv based on proc.

NENCNT4 FUNCTION RN28,D3

is w/ staff physician

.10,1/.2,2/1.0,3
NWSTAFF5 FUNCTION RN30,E2
w/ staff physician
.5,6+(12*FRN29)/1,3+(18*FRN29)
Adv based on proc.

NENCNT5 FUNCTION RN9,D1
w/ staff physician
1.0,3

ROOM STORAGE 8 Non variable
storages
VFROOM STORAGE 1 "
STAFF STORAGE 1 "

************************************************************
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*
*
*
*
*
*
************************************************************

* PROGRAM BEGINS *

GENERATE 28,5,,60,,5PL Generate
stream of patients
TEST LE 240,AC1,PROCESS No patients
after four hours
TERMINATE 0 Death to
XACT!!
GENERATE 0,,,4,,5PL Generate
initial patients

PROCESS TRANSFER .560,,NPROCESS
QUEUE SYSTEM
QUEUE RECEPT
ENTER RECEPT
DEPART RECEPT
ADVANCE 1+4*FRN7 Reception
time
LEAVE RECEPT

ENCOUNT1 ASSIGN 1,FN(ENCOUNT1),PL Call fnctn
for 1st encr attende
e
ENTER PL1
TEST E PL1,1,T1RES Test to see

if w/ tech
ADVANCE FN(WTECH1) LEAVE PL1 TRANSFER ,ENCOUNT2

Transfer to

ADVANCE FN(WRES1) LEAVE PL1

ENCOUNT2 TRANSFER .069,,CHECKOUT Prob of only enctr.

ASSIGN 2, FN(ENCOUNT2), PL Call fnctn for 2nd enctr.
ENTER PL2
TEST E PL2,1,T2RES Test for w/

ADVANCE FN(WTECH2) LEAVE PL2 ADVANCE FN(DILATE) TRANSFER ,ENCOUNT3 Test for w/ T2RES res
TEST E PL2,2,T2STAFF

ADVANCE FN(WRES2) LEAVE PL2 ADVANCE FN(DILATE) TRANSFER ,ENCOUNT3 See staff by T2STAFF default ADVANCE FN(WSTAFF2) LEAVE PL2 Dialiation point in procedure

ADVANCE FN(DILATE) LEAVE PL2

ENCOUNT3 TRANSFER .630,,CHECKOUT Prob of only 2 enctr

ASSIGN 3, FN(ENCOUNT3), PL Call fnctn for 3rd enctr
ENTER PL3 TEST E PL3,1,T3RES ADVANCE FN(WTECH3) LEAVE PL3 ADVANCE DILATE TRANSFER ,ENCOUNT4 T3RES TEST E PL3,2,T3STAFF ADVANCE FN(WRES3) LEAVE PL3 TRANSFER ,ENCOUNT4 T3STAFF ADVANCE FN(WSTAFF3) LEAVE PL3

ENCOUNT4 TRANSFER .400,,CHECKOUT

ASSIGN 4, FN(ENCOUNT4), PL ENTER PL4
ADVANCE FN(WSTAFF4)
LEAVE PL4

ENCOUNT5 TRANSFER .666, CHECKOUT
ASSIGN 5, FN(ENCOUNT5), PL
ENTER PL5
ADVANCE FN(WSTAFF5)
LEAVE PL5

CHECKOUT TEST NE PL2, 3, PAY
TEST G PL2, 0, GETSTAFF
TEST NE PL3, 3, PAY
TEST G PL3, 0, GETSTAFF
TEST G PL4, 0, GETSTAFF
TRANSFER , PAY

GETSTAFF ENTER STAFF
ADVANCE 3 + (18 * FRN35)
LEAVE STAFF

PAY ENTER RECEPT Patient
checks out
ADVANCE 1 + 6 * FRN8
LEAVE RECEPT

DEPART SYSTEM Patient
leaves system

TERMINATE 0

****************************************************************************************************************************
****************************************************************************************************************************
****************************************************************************************************************************

NPROCESS QUEUE SYSTEM
QUEUE RECEPT
ENTER RECEPT
DEPART RECEPT
ADVANCE 1 + 4 * FRN7 Reception

time LEAVE RECEPT

NENCNT1 ASSIGN 1, FN(NENCNT1), PL Call fnctn for
1st enctr attendee
ENTER PL1
TEST E PL1, 1, T1RES Test to see

if w/ tech
ADVANCE FN(NWTECH1)
LEAVE PL1 Transfer to
TRANSFER , NENCNT2

enctr 2 T1RES ADVANCE FN(NWRES1)
LEAVE PL1

NENCNT2 ASSIGN 2, FN(NENCNT2), PL Call fnctn for 2nd enctr.
ENTER PL2
TEST E PL2, 1, T2RES Test for w/ tech
ADVANCE FN(NWTECH2)
LEAVE PL2
ADVANCE FN(NDILATE)
TRANSFER , NENCNT3
T2RES TEST E PL2, 2, T2STAFF Test for w/
ADVANCE FN(NWRES2)
LEAVE PL2
ADVANCE FN(NDILATE)
TRANSFER , NENCNT3
T2STAFF ADVANCE FN(NWSTAFF2) See staff by default
LEAVE PL2
ADVANCE FN(NDILATE) Dialiation point in procedure
NENCNT3 TRANSFER .250, , NCHECK Prob of only 2 enctr
ASSIGN 3, FN(NENCNT3), PL Call fnctn for 3rd enctr
ENTER PL3
TEST E PL3, 1, T3RES
ADVANCE FN(NWTECH3)
LEAVE PL3
TRANSFER , NENCNT4
T3RES TEST E PL3, 2, T3STAFF
ADVANCE FN(NWRES3)
LEAVE PL3
TRANSFER , NENCNT4
T3STAFF ADVANCE FN(NWSTAFF3)
LEAVE PL3
NENCNT4 TRANSFER .580, , NCHECK
ASSIGN 4, FN(NENCNT4), PL
ENTER PL4
TEST E PL4, 1, T4RES
ADVANCE FN(NWTECH4)
LEAVE PL4
TRANSFER , NENCNT5
T4RES TEST E PL4, 2, T4STAFF
ADVANCE FN(NWRES4)
LEAVE PL4
TRANSFER , NENCNT5
T4STAFF ADVANCE FN(NWSTAFF4)
LEAVE PL4

NENCNT5 TRANSFER .800,,NCHECK

ASSIGN 5,FN(NENCNT5),PL
ENTER PL5
ADVANCE FN(NWSTAFF5)
LEAVE PL5

NCHECK TEST NE PL2,3,OUT
TEST NE PL3,3,OUT
TEST G PL3,0,SEESTAFF
TEST NE PL4,3,OUT
TEST G PL4,0,SEESTAFF

SEESTAFF ENTER STAFF
ADVANCE 3+(18*FRN35)
LEAVE STAFF

OUT checks out
ENTER RECEPT
ADVANCE 1+6*FRN36
LEAVE RECEPT

leaves system
TERMINATE 0

GENERATE 240 Control Xact
after four hours
TEST E Q(SYSTEM),0 Test that
all patients have fin
ished
TERMINATE 1

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CONTROL STATEMENTS SECTION

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Interaction section

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