Final Report

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EXECUTIVE SUMMARY
The Kellogg Eye Center at Michigan Medicine conducts genetic counseling, ophthalmic photography, diagnostic electrophysiological testing, and ocular prosthetics, incorporating 9 eye clinics and 6 operating rooms. The attending physicians working in the Low Vision and Neuro-Ophthalmology clinics are concerned that they are not able to see the patients at their exact appointment times. The attending physicians requested that IOE 481 Team 8 from the University of Michigan Industrial and Operations Engineering Department identify the key components responsible for delays between check-in and attending facetime, which is time that the patient is with either clinic staff or provider (residents, fellows, attending physicians) on the third floor of the Eye Center. The team is to deliver high-level recommendations to effectively utilize the technician, resident, fellow, and attending time with patient. Furthermore, the attending physicians believe that the main process bottleneck occurs during the technician work-up time. The general flow of a patient appointment goes as follows: check-in, technician work-up, resident and fellow attending visits, and last, the attending physician visit. Not only were attending physicians worried about not seeing patients at given appointment times, patients were not satisfied with the high variation in alone times prior to seeing a provider. The scope of the project included collecting time studies, interviewing staff and patients, and performing data analysis only for the Low Vision and Neuro-Ophthalmology clinics on the third floor. The two clinics incorporate different procedures and may include different findings.

Methodology
The IOE 481 team used several methods to reach their deliverable. Some of these approaches incorporated work from previous groups as well as the current hospital staff.

Literature Search: The team conducted a literature search on a past IOE 481 report focusing on hospital cases regarding a similarly structured Urology Clinic, to provide guidance with data analysis. This report focused on quantifying the patient flow process in the clinic. Additionally, the team performed literature search on a health sciences journal which discussed options to account for patient variability in a hospital setting.

Observations: The student team performed over 70 hours of observation in the clinics at Kellogg Eye Center. Observations consisted of following patients through the appointment process and recording times that the patient began and completed each step from patient arrival up until the time that the attending physician met with the patient. The team also shadowed technicians throughout the shift, noting the different tasks technicians perform.

Interviews: The IOE team interviewed attending, resident, and fellow physicians, as well as key ancillary staff members, on the third floor to better understand how the overall process in the clinics work and where the delays were believed to occur.

Time Studies: The team collected data on the process barriers through a time study. The time study was conducted under the guidance of the Eye Center manager starting on February 24 until March 10. The ancillary staff, technicians and physicians on the third floor documented each step during a patient’s appointment, beginning with the front desk arrivals until the patient checks out. The sample size for Neuro-Ophthalmology was 73 and Low Vision was 152. The team performed statistical analysis on the collected data from the time study and manual observations in Excel.
Findings and Conclusions
The team created box plots for both clinics which represented several key statistics regarding patient process times, stratified by new patient and return visit patients. These process flow statistics included total appointment length, patient facetime with each provider and staff member, and patient alone time prior to seeing an attending physician.

Insight into Data Collection: The first document, “LSCS Urology Clinic,” described a similar situation at the Urology clinic and provided helpful means for saving time on data collection methods. Specifically, the report focused on staff members at the clinic as the key proponent for data collection. After incorporating this information in their project, the previous IOE team saved a significant amount of time. The second referenced document, “Health Care Management Science,” provided a structure to deal with variability within hospital patients. Based on the time and availability in the day, patients can be batched in groups of 2 to 6 for a single given appointment time.

Observation of Bottlenecks: Prior to the start of the project, the attending physicians expressed concern that the greatest delays occurred during the technician workup time. However, through observation data that the team collected, they found that on average, 72% of the patients experienced the most delay immediately before seeing the attending physicians, which helped indicate that technician workup was not the greatest cause of bottlenecks. In addition, only an average of 4.2% of the total appointment time was spent with the technicians.

Understanding of Process: Through interviews with staff, providers and patients, the IOE team learned that a batch of 2-6 patients are booked at a particular time. The technicians believed that they were able to multitask to meet this quota, however, the attending physicians had a lower chance of fitting this limit due to appointment variability. Additionally, the team learned that the attending physicians believed the patient time spent alone before a technician encounter was the biggest bottleneck in the system.

Analysis of Time study: The IOE 481 team made box plots stratified by clinic type, as well as patient types within the clinic. Overall, the team found that the clinics underestimate the average length of a new patient appointment and overestimate the average length of a return visit patients’ appointment. Based on averages, a new patient takes twice the amount of time in procedure as compared to a return visit.

Recommendations
The team used the findings and conclusions to develop a set of immediate recommendations and future recommendations for both clinics as well as Neuro-Ophthalmology specific recommendations. The following recommendations are the team’s immediate recommendations.

Stagger attending physician schedule to account for patient workup
One of the attending physicians' main objectives was to see patients at the scheduled appointment time, but with patient workups, that is not feasible. Using average process times should help by staggering attending physician schedules to better maximize the attending physician’s time in the clinic.
**Change pre-appointment expectations**
Currently, when patients arrive more than 20 minutes early to an appointment, there is a greater chance of them encountering the technician before their appointment time, in turn increasing the chance of them spending less time in the clinic than the mean. By making it mandatory for patients to arrive 20 minutes early to fill out paperwork, the variability of the difference between appointment time and the time the patient’s appointments begin will decrease.

**Increase number of exam rooms**
Through process observations, the team noticed that the demand for exam rooms exceeds the availability for usable rooms. Specifically, there were instances throughout appointments where the technician and the patient were both available and waiting in the In-Process Waiting (IPW) area until a room became available. This was a contributing factor to the patient wait time alone prior to the technician workup.

The recommendations below include areas the team suggests future projects explore.

**Further investigate similar processes across different clinics to make holistic changes**
There are certain processes that are similar throughout multiple clinics, such as vision field tests, ancillary testing, and photography, among other processes. Since the team observed these processes to be standard across multiple clinics, further investigation needs to be done to determine if these processes make a difference in time spent alone across different clinics.

**Further investigate frequency of cancellations**
Both clinics saw a high level of cancellations. Because cancellations could have an effect on patient throughput, the team suggests further looking at the frequency of cancellations and the number of cancellations that are not filled by another patient.

Below are recommendations specifically for the Neuro-Ophthalmology clinic.

**Decrease the number of starting Wednesday appointments from 6 to 4**
Currently, the third floor of the Eye Center schedules appointments based on a batching system. The current process for the clinic is to schedule six patients at the beginning of the shift and two patients every half hour afterward. By decreasing the number of appointments and spacing the extra appointments out throughout the shift, patient throughput will remain the same, but the proportion of staff and provider facetime versus non-face time will increase because there would be more resources available when there is a smaller batch of patients waiting.

**Manage new patient appointment length expectation**
Currently, the clinic tells new patients that appointments will last between one to three hours, creating an unrealistic expectation for patients. The team noticed that although they were informed of the range, patients expected to leave within an hour. The team recommends telling patients that appointments will take an average of two hours, rather than giving patients a range of possible appointment lengths, which will curb patient expectation.

**Consider implementing consultation appointments to allow for more precise scheduling**
Much of the reason the patient time spent alone is varied is because the patient appointments are highly varied. As shown in the IOE team’s analysis, there is a large range between patient appointment lengths. Because of this high variability, the team suggests instituting a 15-30 minute consultation appointment for every patient.
INTRODUCTION
The Kellogg Eye Center, located in Ann Arbor, Michigan, focuses primarily on patient care, research, and education. The attending physicians on the third floor of the Eye Center reported that they are unable to see a patient at the patient’s given appointment time as a result of bottlenecks within the appointment process that slow patient flow. Additionally, technicians have seen an increase of patient complaints regarding time spent alone throughout the appointment. Before seeing an attending physician, patients must fill out forms, receive a field eye test and complete other necessary examinations.

Furthermore, the attending physicians have noticed that trained technicians are entering patient data into the MiChart system, an online database for Michigan Medicine, during the appointment. The attending physicians believe simple data entry is not the most efficient task allocation of a technician’s skills and time. Ultimately, the attending physicians want to better understand the appointment flow to improve the appointment process and daily operations. The attending physicians would like to know the average amount of time required for a patient to complete the necessary steps prior to being seen by the attending physician and the total portion of time the patient spends alone. With this information, the attending physicians would like recommendations of potential countermeasures the clinic could implement to improve the appointment process.

The IOE 481 team consists of four students studying Industrial and Operations Engineering at the University of Michigan. They worked with two clinics on the third floor: Low Vision and Neuro-Ophthalmology. In the Neuro-Ophthalmology clinic appointment approximations are one to three hours for a new patient, one hour for a return visit and 30 minutes for a procedure. In the Low Vision clinic, appointment approximations are one to two hours for a new patient and one hour for a return visit. Patients experience time alone at numerous steps throughout an appointment because of the high variability in the tasks performed by various staff members and providers. In an ideal situation, the attending physicians would like to see a patient as close to the scheduled appointment time as possible to maximize the attending physician’s working hours per day. Because of this, the attending physicians asked the University of Michigan IOE 481 team to determine what steps of the appointment process cause delays and propose a solution to help decrease patient alone time. The attending physicians would also like data on the average time each step in an appointment takes. The purpose of this report is to present the IOE 481 team’s work, findings and recommendations.

BACKGROUND
The Eye Center is comprised of numerous clinics and satellite campuses. The third floor clinics contain more than 40 attending physicians. For each attending working, there are two to three technicians who enter patient data and run necessary tests. Each attending creates their own schedule template detailing the appointment distribution allotted for each shift. The clinic runs
on a schedule of two shifts per day, one in the morning and one in the afternoon.

There are three different types of patients that are seen at the Neuro-Ophthalmology clinic: New Patient, Return Visit, and Procedure. There are two types of patients in Low Vision clinic: New Patient and Return Visit. A typical patient appointment usually includes the same steps, which are as follows:

1. Check-In & Complete Paperwork
2. Technician Workup
3. Resident and Fellow Physician Visits
4. Attending Physician Visit

The flow of each appointment differs depending on staff and room availability, as well as the number and type of tests needed. The process for this flow is seen in Figure 1.

Figure 1: General Patient Appointment Flow

The general patient appointment flow is for the Low Vision clinic is essentially identical to that of the Neuro-Ophthalmology clinic. Since every appointment at the hospital is subject to variation, the team has accounted for individual patients while recording the data.

**Check-In**
When patients arrive at the office for an appointment, they are greeted at the front desk. This step usually has little to no wait time. At the front desk, patients are given a packet of paperwork to complete and directed to the corresponding clinic’s waiting area. One form includes questions about symptoms, medications used, allergies, pharmacy information, and smoking history. Another form contains information on the patient’s personal and familial, medical and ocular history. Current patients are given a copy of their most recent paperwork and asked to review and update the information with any changes. The Eye Center recently launched E-Check In,
which allows patients to fill out the paperwork online, enabling them to skip the paperwork process upon arrival to the Eye Center. While approximately 50% of current patients are signed up for E-Check In, only 5-15% of patients actually utilize E-Check In to fill out pre-appointment paperwork.

**Technician Workup**

Once a technician is free and an exam room is available, a patient is brought back to begin the process. If the patient uses E-Check In, the new or updated information is highlighted in the system, requiring the technician to simply review the changes with the patient. If the patient fills out paperwork instead of using the E-Check In option, the technician must manually enter data into MiChart and confirm all the new information or changes from the patient’s paperwork. The technician then performs an eye field test and runs additional tests depending on the patient’s condition. Time spent with a technician varies depending on the type of appointment and patient. The patient’s mobility, age and symptoms are all factors that affect the amount of time it takes the technician to perform tests on the patient. Once all needed tests are completed, the technician takes the patient to a row of chairs where the patient waits for an exam room.

**Resident Physician and Fellow Physician Visits**

Following the technician testing, the patient is escorted to the first available exam room. The patient is then visited by a resident physician, who reviews the symptoms and performs any other necessary tests. After the resident is finished, the patient meets with a fellow physician. The fellow also asks questions about the patient’s symptoms and reviews previous testing. Depending on the available staff and patient condition, a patient may see both a resident and fellow, one or the other, or neither. Procedure appointments in the Neuro-Ophthalmology clinic do not include a resident or fellow visit. The resident and fellow physician visits are unique to the teaching environment at Michigan Medicine.

**Attending Physician Visit**

The last step of a patient’s visit is a meeting with the attending physician. The attending physician allot about 5 to 20 minutes with the patient depending on the type of appointment and the patient’s needs.

During busy hours, the appointment flow is not always smooth due to the complexity and variability of each appointment. Depending on how busy the shift is, a patient experiences varying alone time between each of the steps mentioned above. Some patients become impatient and frustrated with the numerous periods of time spent alone. Currently, the clinic schedule does not provide the attending physician with adequate information regarding when the patient will be done with testing and ready to been seen. Attendings often encounter idle time at the beginning of their shifts because the patients are receiving testing from technicians. This creates an inefficiency because attendings have idle time, which decreases the amount of patients that can
be seen. For example, a patient with an appointment at 1:00pm often does not see the attending until 1:45pm at the earliest. Even if the attending is free at 1:00pm, the attending cannot see the patient until all other steps in the patient’s visit are completed.

**KEY ISSUES**
The following issues are driving the need for this project:

- Unpredicted variability in the processes prior to the attending physician visit, which causes delays
- Limited resources (rooms and technicians) cause bottlenecks in the queue, which results in long periods of time where patients are alone.
- Inefficient task allocation for technicians entering data

**GOALS AND OBJECTIVES**
To determine where in the appointment a patient experiences long periods time spent alone, the team achieved the following tasks:

- Reported the time to complete each step in the appointment process
- Found the average amount of time a patient spends alone during an appointment
- Determined which part(s) of the appointment is creating a delay

With this information, the team developed recommendations to:

- Reduce overall patient alone time
- Increase patient and employee satisfaction
- Increase patient throughput
- Manage patient expectations by providing transparency on approximate appointment length

**PROJECT SCOPE**
The scope of this project included only the patient appointment process in the Neuro-Ophthalmology and Low Vision clinics on the third floor of the Eye Center. The process begins when a patient first enters the clinic for check in and ends when the patient is seen by the attending physician.

The project will not consider tasks that do not pertain to the clinic on the third floor of the Eye Center. Specifically, the project will not include the time that the attending is seeing the patient or the patient care. Additionally, the project will not address the layout of the Eye Center.
METHODS
The IOE 481 team used a variety of methods to approach the appointment inefficiencies. A literature search was conducted to gain a base understanding of how to begin the project. The team used observations and interviews to develop a high-level understanding of the clinic processes. The team then developed a time study to collect the majority of the data necessary for analysis. Finally, the team performed statistical testing through Microsoft Excel to draw conclusions and develop recommendations from the data collected.

Literature Search
The team searched the University of Michigan’s IOE 481 database of previous projects to gain insight on previous projects on clinic flow and time study implementation. In addition to previous projects, the team used Google Scholar to find articles pertaining to improving the efficiency of a medical appointment.

Observations
To observe the appointment process at the Eye Center, the team utilized two different methods. The first was to follow a patient through the entire appointment process. This method also included conversing with managers and providers to better understand which parts of the appointment process creates bottlenecks. The team was able to get a first-hand perspective of the process and directly observe the bottlenecks within the process. Using this method, the team was able to accumulate 70 hours of direct observation.

The second method used was shadowing the technicians. One key issue driving the project was that attending physicians believe there is an inefficient task allocation amongst the technicians. Because of this, the team wanted to directly observe the efficiency of the technicians’ work in the process. Using this method, the team was able to observe 20 patient workups by technicians.

Through these two methods of observations combined with key interviews, the team identified major barriers within the appointment process.

Interviews
To get a better sense of the appointment process in addition to observations, the team also interviewed key staff and providers on the third floor of the Eye Center. The specific members interviewed were clinic managers, technicians, resident physicians, fellow physicians and attending physicians.

When interviewing floor managers, the team wanted to determine how appointments were scheduled. Two floor managers were interviewed about exactly how this process works. The floor managers were also asked general questions about potential bottlenecks in the system.
As mentioned previously, there was a concern about inefficient task allocations amongst the technicians. Because of this, the team interviewed five technicians for opinions of this concern. The team also asked the technicians where bottlenecks had been observed and what has been done to decrease the time patients spend alone.

The team also interviewed several residents and fellows as well as two attending physicians to try to understand the issue from a different perspective. The team wanted to know how the attendings felt about the patient time spent alone and if it was a problem that patients had brought up in the past.

**Time Study**

The team collected data on the appointment process through a time study. The time study was implemented in the clinics from February 24, 2017 to March 10, 2017. The time study was conducted under the guidance of the Eye Center manager. In the time study, technicians on the third floor documented each step of the appointment process, ranging from the front desk arrivals to the time the attending sees the patient. The sample size for the time study was 225 patients. The time study was carried out specifically in the Neuro-Ophthalmology and Low Vision clinics.

The time study form [A2] was developed by the IOE team based on the checkpoints during the appointment, as determined by observations. The process for each time study started off at the front desk, where the front desk staff had a new sheet for every patient that came into the clinic on the third floor of the Eye Center. The front desk staff recorded the patient arrival time and the appointment type. The staff then handed the sheet to the patient, who gave it to the technician. The technician placed a patient information sticker (provided by the clinic for each patient) on the sheet and logged the arrival and departure time for any testing performed on the patient. The technician then passed along the sheet for the fellow, resident, and attending physician to log the respective arrival and departure times.

Finally, the IOE team used the collected data to find an average for each step in the check-in process. This average allowed the team to determine a standard work time for each step, which continued to be helpful in analyzing the data.

The data collected from time study and manual observation was stored in Excel and separated by clinic and patient type. The team analyzed the data and created box plots to visually display the data and highlight significant trends. The team identified the average total time spent by a patient, as well as the amount of time each type of provider spends with a patient during an appointment. The team then determined how long patients spent alone without a provider. The patient may spend time alone for a variety of reasons, including waiting for a cream or medicine to take effect, waiting for an open room, or simply waiting for a provider. Lastly, the team found the average amount of time that a patient spent in an appointment before they were seen by the
attending and the amount of time a patient spent in an appointment before they were ready to be seen by the attending.

FINDINGS AND CONCLUSIONS
Using the methods listed above, the IOE Team was able to draw various findings and conclusions.

Insight into Data Collection
The previous IOE 481 project report for the Urology Department provided detail for the time study that was implemented. Specifically, the report found staff members of a Urology clinic were more reliable than patients in filling out the time study form [1]. At the Eye Center, many patients are legally blind or have trouble seeing, so the team would not be able to rely on patients to fill out a time study sheet throughout the appointment. Having staff members and providers complete the time study sheet was a helpful idea because it allowed the team to collect more data points than if just the four team members were performing the time studies. The report also contained a value stream map of the current clinic process, identified bottlenecks, and proposed how to reduce the time a patient spent in clinic and improve the percentage of value-added time. The paper analyzed the factors that contribute to the amount of time an appointment takes. The patient arriving late, waiting for the MA, and waiting for the attending physician were the top three reasons for an appointment length of over an hour.

The second study was published in the Health Care Management Science journal. This report focused on improving the patient flow by performing a clinic study and identifying sources of variability [2]. The article used the analyzed variability to predict the time a given appointment takes, ultimately decreasing patient wait times and attending physician finish times. The clinic was able to see 37% more patients with the suggested improvements. One improvement made was not batching patients in large groups. The IOE team plans to use this information by incorporating a potential change in patient batch sizes. Specifically, the team will analyze the scenario where patients are grouped in smaller batches prior to scheduling.

Observation of Bottlenecks
When observing the technicians, the team observed that the time for data entry was very small when compared to the total workup time. The time the technicians spent solely entering data into MiChart was between three and five minutes. This short time frame also includes the time the technician asked and confirmed the patient data, which is required by federal law. Additionally, the technicians would often multitask by starting exams with the patient and entering the patient data simultaneously. Last, the team observed that bottlenecks were occurring after the technician workup, which shows that the time to enter data is not greatly affecting the current appointment flow.
The team noticed, specifically in the Neuro-Ophthalmology clinic, that patients were commonly upset about appointment times lasting longer than the expected time given of 1 to 3 hours. More importantly, though, patients seemed to think that appointment lengths would be closer to 1 hour and became upset when that time frame was not met.

While observing the entire appointment in Neuro-Ophthalmology, the team observed that patients spent an average of less than eight minutes alone between checking in and being seen by a technician. One of the main reasons a patient was not seen by a technician at the patient’s given appointment time was because there was not an examination room available. The attending physician was observed to be in demand most often as a shift progressed. In Low Vision, patients spent more time alone before being seen by a technician, not the attending.

Combining the information from the interviews, the team identified the attending encounter appointment as a heavy bottleneck in the process. This conclusion was confirmed by both direct observations and interviews, and the team also found an accumulation of patients spending time alone after the check-in and before technician checkups. The team found that more than 72% of the patients experienced the most time spent alone after the workup but before seeing the attending. Following the findings, the IOE team identified these areas as key pain points within the process, which were the two waiting areas before the patients saw the residents, fellows, and attending.

**Understanding of Process**

When speaking with the Eye Center floor managers, the team learned that each attending creates their own preferred schedule template, outlining what type of patient should be scheduled at a given time.

Through interviews with technicians, the team learned that most of the technicians multi-task by entering patient data while conducting field tests. The technicians interviewed did not believe entering patient data was incredibly time consuming because the technician is required by law to confirm the data. However, it was noted that there are some instances that new patients have a lot of medications or family history that needs to be added which can take up to 30 minutes, but it is not a frequent occurrence. The findings from the technician interviews validated the team’s conclusion from observations that data entry does not take up a significant amount of time during the patient workup.

When attending physicians were interviewed, the team learned that there was some discrepancy between patient facetime and their scheduled appointment time. The attendings also explained that the gap between the times increases further into the shift. The attendings believe this could be the result of bottlenecks caused by other issues, which result in patients getting backed up. The attendings hope to identify some possible sources for these distinct bottlenecks.
Analysis of Time Study
Using the time study, the team was able to collect data on 225 appointments. 73 appointments were from the Neuro-Ophthalmology clinic and 152 appointments were from the Low Vision Clinic. The data was entered into Excel and different metrics were calculated using the methodology explained above. The team analyzed the clinics as separate entities.

The team considered patient time spent alone, as any time spent without a provider. The team was unable to differentiate between time spent alone and mandatory time spent alone. Mandatory time spent alone is time it would not be possible for the patient to be seen. Some examples would be when the patient’s eyes needed to dilate or a patient needing numbing cream to set for a certain period of time. Additionally, the time with attending is the cumulative time with an attending. If an attending visited a patient multiple times the total amount of time was used. Furthermore, sometimes the time spent with one provider was with a patient was very long, some of these instances could be due to a provider going in and out and not filling out the time study sheet each time.

Neuro-Ophthalmology Clinic
Depending on the day, the neuro-ophthalmology clinic will see anywhere from 12 to 24 patients based on the clinic’s scheduling template. During the time study, one attending saw an average 17 patients per shift. During the time study, 32% of the appointments were cancelled and 72.6% of patients arrive early by an average of 20 minutes. Of the patients that arrived early 32.8% of saw a technician before the scheduled appointment time.

Length of Appointments in Neuro-Ophthalmology
The appointment length is defined as the time the appointment is engaged, defined as when workup begins until the time the patient checks out. Figure 2 displays the appointment length stratified by the type of appointment.
Figure 2: Neuro-Ophthalmology Appointment Length from Engagement to Checkout

New patients in the Neuro-Ophthalmology clinic are told that the appointment will take anywhere from 1 to 3 hours. The appointment length of a new patient varied from 1 hour to 4 hours and 50 minutes, with a median of 2 hours and 22 minutes. Figure 2 shows that more than 75% of new patient appointments are within the 3 hour estimate, however there is room for refinement with the outliers lasting almost 5 hours. For procedures in the Neuro-Ophthalmology clinic, the appointment length varied depending on whether a patient needed numbing cream applied before the procedure. If numbing cream was needed, the patient would have to spend 45 minutes alone after application until the patient could have the procedure done. Although the return visits spent a significantly less amount of time in their appointments than new patients, the median appointment time was still 1 hour and 36 minutes.

*Time Until Attending Encounter in Neuro-Ophthalmology*

The average time the patient spends in the clinic before encountering the attending or undergoing a procedure was calculated from the appointment time. The average time before a patient is seen by an attending is displayed in Table 2, stratified by appointment type.
Table 1: The Average Time Before the Attending Sees a Patient in the Neuro-Ophthalmology Clinic

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Average Time from Appointment Time to Attending Encounter (hr:min)</th>
<th>Average Time from Appointment Engagement to Attending Encounter (hr:min)</th>
<th>Number of Appointments</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP</td>
<td>1:50 ± 00:44</td>
<td>1:41 ± 00:43</td>
<td>16</td>
</tr>
<tr>
<td>RV</td>
<td>1:10 ± 00:47</td>
<td>1.150 ± 00:43</td>
<td>22</td>
</tr>
<tr>
<td>Procedure</td>
<td>00:43 ± 00:28</td>
<td>00:41 ± 00:25</td>
<td>30</td>
</tr>
</tbody>
</table>

As shown in Table 1, a new patient takes over twice the amount of time as a procedure before the patient can be seen by the attending. This difference can be attributed to the additional tests and workup needed before a new patient can see the attending. Return visits require less tests before being seen by the attending. The information in Table 1 allows the attending to better schedule work time in a given day when the patient type distribution is known.

Length of Each Step in the Appointment in Neuro-Ophthalmology

In order to better understand the appointment flow, the time of each step in an appointment was plotted. The time with the attending is the cumulative time the attending saw the patient throughout an entire appointment. The team was unable to receive time study data from a large number of residents and fellows. Figure 3 displays the length of each step in a new patient appointment.

Figure 3: Time for Each Step in a Neuro-Ophthalmology New Patient Appointment

Source: Time study data. Technician Workup N=9; Resident Workup N=6; Visual Field N =7; Fellow N=4; Attending N=16
For new patients in the Neuro-Ophthalmology clinic, the longest step in the process was when the patient was with the workup, performed by a technician and resident, which was on average 17% of the overall appointment length. Through observations, the team saw the variability of appointments and used this information to help interpret the results. The team observed that sometimes the resident will take patients back and perform the workup as well as perform additional tests. This observation was displayed in the time study and Figure 3, the resident started the appointment and completed the workup, which explains why the median for the time with the resident is greatest.

Figure 4 displays the length of each step for a return visit appointment.

![Figure 4: Length of Each Step in a Return Visit Appointment in Neuro-Ophthalmology](image)

**Step in Appointment**

- Technician Workup
- Ancillary Testing
- Visual Field
- Resident
- Attending
- Procedure

Source: Time study data. Technician Workup N=21; Ancillary Testing N=3; Visual Field N =6; Resident N=3; Attending N=15; Procedure N=7

In Figure 4, the time a patient spends with a technician and resident were the greatest median times. Of the 24 return visits the team had data on, 21 patients had a workup with the technician and the other 3 were performed by the resident. While the median length of the attending encounter is similar to a new patient appointment, the variability is much higher, which could mean that return visit appointments could be more complicated.

Figure 5 displays the length of each step for a procedure appointment.
Figure 5: Time for Each Step in a Neuro-Ophthalmology Procedure Appointment

For a procedure, a patient only sees the technician and attending as shown in Figure 5. The technicians prepare the patients for the procedure which explains the longer time with the technician shown. The average time for the attending to perform a procedure was 7 minutes. The low variability confirms the consistency of an expected procedure time, which can aid in scheduling process.

**Patient Time Spent Alone Appointment in Neuro-Ophthalmology**

Patient time spent alone was defined as the time a patient was not with a provider. Figure 6 displays the cumulative amount of time per appointment a patient spent alone, stratified by appointment type.
As shown in Figure 6, the median time spent alone for new patient appointments is 50 minutes, return visits is 33 minutes, and procedure appointments is 24 minutes. The median amount of time spent alone correlates with the complexity of each type of appointment and the availability of necessary resources, which includes exam rooms and providers. The pie charts in Figure 7 display the average cumulative time a patient spends alone compared to the average length of the appointment.
Figure 7 shows a patient will spend about 4 minutes alone for every one minute with an attending, independent of patient appointment type.

The time the patient spent alone before the technician was calculated as the time between the scheduled appointment time and when the workup began. In certain instances, patients were seen before the scheduled appointment time, which meant the time spent alone before the workup was zero. For the time spent alone before being seen by the attending it is a cumulative total if the patient had more than one encounter with the patient. Figure 8 displays the time the patient spent alone before each step in a New Patient Appointment.

Figure 8: Time Patient Spent Alone Before Each Step in a Neuro-Ophthalmology New Patient Appointment

![Time Patient Spent Alone Before Each Step in a Neuro-Ophthalmology New Patient Appointment](image)

Source: Time study data. Technician Workup N=13; Resident Workup N=6; Visual Field N =7; Attending N=9

In Figure 8, the median patient time spent alone before the attending encounter was 51 minutes, which is significantly higher than the time spent alone before the other steps of an appointment. The demand for the attending is high because there is only one working per shift. The patient time spent alone before the workup with the technician was the least as many patients were seen by the technician before the scheduled appointment time.

Figure 9 displays the time the patient spent alone before each step in a Return Visit.
Figure 9: Patient Time Spent Alone Before Each Step of a Return Visit in Neuro-Ophthalmology

As seen with the new patient appointments in Figure 9, return visit patients also had the least amount of time spent alone before seen by a technician and the most amount of time spent alone before seen by the attending. As previously stated, the time spent alone before the resident encounter was when the resident performed the workup of the patients and there were only 3 out of 24 visit who had this. The small sample size can skew the data for the time spent with the resident. However, compared to new patient appointments the time spent alone was much shorter for return visits. Combining the low median with the high variability of the time spent before seeing the attending, it shows that while half of return visit appointments spend about 12 minutes alone, when the median time is exceeded the time alone is significantly longer.

Figure 10 displays the time the patient spent alone before each step for a procedure appointment.
In Figure 10 the median time spent alone before a procedure with the patient is 6 minutes. This is the shortest out of all of the appointment types. Some patients needed numbing cream which needs 45 minutes after application until the procedure can be performed. The time could have been accounted in part of the time with the technician. Based on Figure 5 and Figure 10, the variability in a procedure appointment is mainly due to the time spent alone before seeing a technician.

**Low Vision Clinic**

Depending on the day, the Low Vision clinic will see an average of 43.7 patients per day. There are usually anywhere between 2 to 4 attending physicians working per shift. During the time study period, the Low Vision clinic saw a high rate of cancellations with a rate of 47%. Additionally, 71% of patients arrived early to the Low Vision clinic and 25.9% of patients saw a technician before the scheduled appointment time.

**Length of Appointments in Low Vision**

The appointment length is defined as the time from the scheduled appointment time to the time the patient checked out. Figure 11 displays the appointment lengths for patients of the Low Vision clinic, stratified by the type of appointment.
The appointment length of a new patient varied from 22 minutes to 2 hours and 11 minutes, with a median of 1 hour. The appointment length of a return visit patient varied from 19 minutes to 4 hours and 6 minutes, with a median of 56 minutes. The appointment began as soon as the patient was taken back and ended when the patient checked out. This eliminated any outliers of patients that may have been brought back before their appointment time. On average, new patient appointments in the Low Vision Clinic were just slightly longer than return visit appointments and both variances were fairly small. Since both new patient and return visit have similar medians and low variability, it shows that there is not a huge difference between new patient and return visit appointments. However, if one appointment is less complex, the less complex appointment should take less time.

**Time Until Attending Encounter in Low Vision**

The average time the patient spends in the clinic before encountering the attending or undergoing a procedure was calculated from the appointment time and the appointment engagement. The average time before a patient is seen by an attending or undergoes a procedure is displayed in Table 2, stratified by appointment type.
Table 2: The Average Time Before the Attending Sees a Patient at the Low Vision Clinic

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Average Time from Appointment Time to Attending Encounter (hr:min)</th>
<th>Average Time from Appointment Engagement to Attending Encounter (hr:min)</th>
<th>Number of Appointments</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP</td>
<td>00:32 ± 00:22</td>
<td>00:28 ± 00:17</td>
<td>50</td>
</tr>
<tr>
<td>RV</td>
<td>00:31 ± 00:17</td>
<td>00:27 ± 00:14</td>
<td>66</td>
</tr>
</tbody>
</table>

Although it is assumed new patients require more attention since it is the patient’s first time visiting the clinic, the average time before meeting with the attending is almost the same for new patients and return visits, as shown in Table 2. This shows that the Low Vision clinic is consistent when completing the tasks necessary in an appointment.

**Length of Each Step in the Appointment in Low Vision**

In order to better understand the appointment flow, the time of each step in an appointment was plotted. The time with the attending is the cumulative time the attending saw the patient throughout the entire appointment. The team was unable to receive time study data from a large number of residents and fellows.

Below, Figure 12, displays the length of each step for a new patient appointment in the Low Vision clinic.

![Figure 12: Time for Each Step in a Low Vision New Patient Appointment](image)

Source: Time study data. Technician Workup N=57; Resident & Fellow N=4; Procedure N=7; Attending N=49;
For new patients in the Low Vision clinic, the longest step in the process was being seen by the attending. The data shown includes 49 patients that saw the attending and 57 patients that saw a technician. The box plot shows the low variability in the time spent with the technician. The first and third quartiles of the time spent with a technician are relatively close to one another compared to the time spent with the attending. Time spent in each step is fairly similar throughout the new patient appointments, however, there is higher possibility of outliers when a patient sees the attending.

Figure 13 displays the length of each step for a return visit appointment in the Low Vision clinic.

![Figure 13: Time for Each Step in a Low Vision Return Visit Appointment](image)

Source: Time study data. Technician Workup N=81; Resident & Fellow N=4; Procedure N=4; Attending N=66;

As shown in Figure 13, the longest step in a return visit patient’s appointment was being seen by a resident or fellow. There were only four data points, however, so it is difficult to make any concrete conclusions. The data shown includes 66 patients that saw the attending and 81 patients that saw a technician. Again, the box plot shows low variability in the time spent with the technician since the first and third quartiles of the time spent with a technician are relatively close to one another. The time spent with the attending was usually longer than the time spent with a technician and there was a much wider range. The time spent with the resident or fellow had much more variability. Through observation, the team saw that residents or fellows sometimes took patients back to perform the workup and additional tests themselves, eliminating the need for the patient to see the technician at all.
**Patient Time Spent Alone Appointment in Low Vision**

Patient time spent alone was defined as the time a patient was not with a technician, resident, fellow or physician. Figure 14 displays the cumulative amount of time per appointment a patient spent alone, stratified by appointment type.

**Figure 14: Total Time Patients Spend Alone in a Low Vision Appointment**

![Box plot showing time spent alone by new patient (NP) and return visit (RV) patients.](image)

Source: Time study data. NP N=64; RV N=88

As shown in Figure 14, the median time a new patient spends alone is 16.2 minutes and the median time a return visit patient spends alone is 10.2 minutes. Because a new patient tends to require more testing than a return visit, it is understandable that they spend a total of 6 more minutes alone between each step of their appointment. Once again, Figure 14 shows that there is a small difference between the two types of appointments.

Figure 15 displays the average time a patient spent alone compared to the average time a patient spent with the attending during an appointment, stratified by appointment type.
Figure 15: Patient Time Spent Alone versus Time with Attending in Low Vision

Source: Time study data. New Patient N=49; Return Visit N=66

The pie charts in Figure 16 display the average cumulative time a patient spends alone compared to the average length of the appointment. Both new patient and return visit patients in the Low Vision clinic spend just about the same amount of time with the attending as they did alone. Since there is a minimal difference between time spent alone and time spent with a patient, the clinic has proven to be operating at a high level of efficiency.

The time the patient spent alone before the technician was calculated as the time between the scheduled appointment time and when the workup began. The time spent alone before being seen by the attending was a cumulative total of time spent alone prior to seeing the attending, even if the patient had more than one encounter with the patient.

Figure 16 displays the time the patient spent alone before each step in a New Patient Appointment in the Low Vision clinic.
Figure 16: Time Patient Spent Alone Before Each Step in a Low Vision New Patient Appointment

Source: Time study data. Technician Workup N=62; Resident & Fellow N=4; Procedure N=3; Attending N=46;

As shown in Figure 16, new patients spent the most time alone before a procedure. This may be attributed to necessary preparation for a procedure, such as waiting for numbing cream to take effect. The median patient time spent alone before undergoing a procedure was 39 minutes but the range was 49 minutes. The median time spent alone before a technician encounter was 4 minutes and the median time spent alone before a resident or fellow encounter was only 3 minutes. The median time spent alone before seeing an attending was 12 minutes which was greater than the time spent alone before seeing a technician, resident or fellow encounter. This extra 8 minutes of alone time is understandable due to the high demand of the limited number of attending physicians.

Figure 17 displays the time the patient spent alone before each step in a Return Visit appointment in the Low Vision clinic.
As shown in Figure 17, Return Patients spent roughly 10 minutes when alone before seeing a technician, the attending or undergoing a procedure. The median time spent alone prior to seeing a resident or fellow was 0 minutes. Since, once again, the time spent alone before each step is similar between a new patient and a returning visitor, the two types of appointments have very little differences. Figure 18 displays the time a patient spends alone. This is an average of both new patient and return visit appointments.
Figure 18 shows that the time spent waiting for the attending and a procedure make up a majority of the overall wait time (around 70%).

RECOMMENDATIONS
The team used the findings and conclusions to develop a set of immediate recommendations and future recommendations for both clinics as well as Neuro-Ophthalmology specific recommendations.

Immediate Recommendations
The immediate recommendations were developed for both the Neuro-Ophthalmology clinic and Low Vision clinic. The recommendations require less work to implement than future recommendations.

Stagger attending physician schedule to account for patient workup
The data collected by the IOE team shows that the time between a patient’s appointment time and when a patient sees attending physician in Neuro-Ophthalmology is 110 minutes (1.833 hours) for a new patient, 70 minutes (1.167 hours) for a returning patient, and 43 minutes (0.717 hours) for a procedure. While in the Low Vision clinic, the length is 46 minutes (0.77 hours) for a new patient and 31 minutes (0.517 hours) for a returning patient.

One of the main objectives that the attending physicians wanted was to be able to see patients at the scheduled appointment time, but with patient workups, that is not feasible. Using average work up time for the patient distribution the attending physician’s schedule can be staggered to better minimize the attending physician’s idle time in the clinic. This will create two different schedules, one for when a patient is told to arrive and one which factors in the average work up time to calculate when the attending will start seeing patients. For example, if the physician has two new patients and two procedures at the beginning of a shift using the median work up time the attendings schedule will be shifted later to account for the patient work up time. This will give the attendings more time to focus on other work such as calling patients or attending meetings and then when the attending begins working patients will be ready to be seen.

Change pre-appointment expectations
Currently, when patients arrive more than 20 minutes early to an appointment, especially at the beginning of a shift, there is a greater chance of the appointment beginning before the scheduled appointment time. Currently, patients are not told to arrive early for an appointment and when patients arrive early it happens by chance and habit deepening on the patient. The team noticed that the early arrival of patients allows technicians to begin the workup earlier than the scheduled appointment time. When appointments at the beginning of the shift started early, it allowed the attending to see the patient faster and allowed the clinic to free up exam rooms. Instead of
leaving it up to chance, the team recommends the clinics ask patients to arrive 20 minutes early. By making it mandatory for patients to arrive 20 minutes early to fill out paperwork, the variability of the difference between appointment time and the time the patient’s appointments begin will decrease. This behavior can be further reinforced by implementing a penalty for patients that do not arrive 20 minutes before their appointment time.

**Increase number of exam rooms**

Through process observations, the team noticed that the demand for exam rooms exceeds the availability for usable rooms. Specifically, there were instances throughout appointments where the technician and the patient were both available and waiting in the In-Process Waiting (IPW) area until a room opened. This was a contributing factor to the patient wait time alone prior to the technician workup. Another suggestion could also be to coordinate with the other appointment types to use open rooms although they may not technically be assigned to the Neuro-Ophthalmology clinic.

**Future Work Recommendations**

The following recommendations pertain to both the Neuro-Ophthalmology and Low Vision Clinics and can be implemented by the attendings at a later date or further investigated by other project teams.

**Further investigate similar processes across different clinics to make holistic changes**

With large differences between individual clinic’s patient flow, it is difficult to compare each clinic’s appointment process to each other. However, there are certain processes that are similar throughout multiple clinics. Since the team observed these processes to be standard across multiple clinics, further investigation needs to be done to determine if these processes make a difference in time spent alone across different clinics. Some of the processes included vision field tests, ancillary testing, and photography, among other processes.

**Further investigate frequency of cancellations**

Both clinics saw a high level of cancellations — the Low Vision clinic had a 47% cancellation rate and the Neuro-Ophthalmology clinic had a cancellation rate of 32%. Because cancellations could have an effect on patient throughput, the team suggests further looking at the frequency of cancellations and the number of cancellations that are not filled by another patient.

**Neuro-Ophthalmology Recommendations**

Below are recommendations specifically for the Neuro-Ophthalmology clinic. The Low Vision clinic does not have further recommendations because from the data when compared to Neuro-Ophthalmology, the clinic has less variability and time spent alone.
**Decrease the number of starting Wednesday appointments from 6 to 4**
Currently, the third floor of the Eye Center schedules appointments based on a batching system. The current process for the clinic is to schedule six patients at the beginning of the shift and two patients every half hour afterward. However, the current system creates a bottleneck at the attending encounter when patient appointments take longer than the average time. This happens on Wednesday in the Neuro-Ophthalmology clinic, when four new patients are batched together with two injection appointments.

Because of the team’s observation that there was a shortage of rooms, by decreasing the number of starting Wednesday appointments and spacing the extra appointments out throughout the shift, patient throughput will remain the same, but the proportion of staff and physician face time versus non-face time will increase because there would be more resources available when there is a smaller batch of patients waiting.

**Manage new patient appointment length expectation**
As shown in Figure 2, a new patient appointment takes a median of 2 hours and 22 minutes. However, as stated previously, there are outliers where the appointment lasted almost five hours from the scheduled appointment time.

Currently, the clinic tells new patients that appointments will last between one to three hours, creating an unrealistic expectation for patients. Through observations, the team noticed that although they were informed of the range, patients expected to leave within an hour. The appointment approximation, in turn, caused a decrease in patient satisfaction when appointments take longer than that. The team recommends telling patients that appointments will take an average of two hours and not give patients a range of possible appointment time lengths. This will curb patient expectation.

**Consider implementing consultation appointments to allow for more precise scheduling**
Much of the reason the patient time spent alone is varied is because the patient appointments are highly varied. As shown in the IOE team’s analysis, there is a large range between patient appointment lengths. Because of this high variability, the team suggests instituting a 15-30 minute consultation appointment for every patient. The appointments may be scheduled in 15-30 minute blocks on a single day, allowing the attending to assess each patient and provide insight to the scheduler when setting up the patient’s next appointment. The consultation appointments would be strictly capped at 30 minutes so the attending would never be running late and cause a bottleneck. The appointments could either take place in-person or over the phone.

**EXPECTED IMPACT**
The recommendations provided by the team will decrease the time patients spend alone at the Eye Center by eliminating wasted time in the check-in process. Specifically, the
recommendations will:

- Reduce patients’ overall alone time in the process
- Maximize task allocation efficiency
- Level the scheduled appointment times with the facetime
- Increase patient and employee satisfaction of the process
WORKS CITED


APPENDIX

A1. Time Study Data Collection Instructions

Data Collection Instructions

We are a team of Industrial Operating Engineering students working with Dr. Jerome Finkelstein to improve the processes on the third floor of the Kellogg Eye Center, which will ultimately reduce patient wait time.

To do this, we ask for your help in collecting data. As you see on the data collection form, we are asking that you log the time of each patient as they go through the check-in process all the way until the patient checks out.

Steps:

1. **Front desk staff** will start a new data collection sheet for each visitor as they walk in. Please the apt. time and patient type information at the top of the sheet.

2. **Front desk staff** will give sheet to patient as part of packet with rest of necessary papers.

3. **Patient** will hand data collection sheet (as part of necessary papers) to **technician** once called.

4. **Technician** will place patient info sticker on sheet.

5. **Technician** will log in and out time of the work up as well as any other testing done (ancillary testing, visual field).

6. **Technician** will place data collection sheet into folder for

7. **Fellow** will log in and out time that they see a patient.

8. **Resident** will log in and out time that they see a patient.

9. **Attending** will log in and out time that they see patient.

10. **Check out staff** will collect sheets in basket.
# A2. Time Study Form

Date: ____________  Scheduled Appointment Time: ___ : ___ AM / PM  Provider: Select One

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<th>Patient Type: Select One from Each</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>□ NP  □ RV  □ Internal Referral  □ Post Op  Y / N Wheelchair</td>
<td>□ Male  □ Female</td>
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</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Staff</th>
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<th>End Time</th>
<th>Notes</th>
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<tr>
<td>Vitals</td>
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<tr>
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<td>Tech Work Up</td>
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<td>IPW</td>
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<td>Check Out</td>
<td>Check-out Staff</td>
<td>___ : ___</td>
<td>___ : ___</td>
<td></td>
</tr>
</tbody>
</table>

Source: Time study data. NP N=17; RV N=24; Procedure N=31

A4. Neuro-Ophthalmology Appointment Length from Appointment Engagement until Checkout

Source: Time study data. NP N=17; RV N=24; Procedure N=31
A5. Low Vision Appointment Length from Scheduled Appointment Time until Checkout

Source: Time study data. NP N=52; RV N=68

A5. Low Vision Appointment Length from Appointment Engagement until Checkout

Source: Time study data. NP N=50; RV N=66