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# The Process by which Physicians Extract Information from Electronic Progress Notes During Handoffs

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# THE PROCESS BY WHICH PHYSICIANS EXTRACT INFORMATION FROM ELECTRONIC PROGRESS NOTES DURING HANDOFFS

A Thesis Presented
By
Brian Amster

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Mechanical and Industrial Engineering

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Mechanical and Industrial Engineering

# DEDICATION

To my Parents and Nani

**ACKNOWLEDGMENTS**

I would like to thank my advisor, Professor Jenna Marquard, for her guidance, encouragement, and support. Many thanks to the members of my committee, Professors Donald Fisher, Adrian Staub, Matthew Romoser and Patrick Brown, for their valuable comments and suggestions.

I would also like to thank, Professor Jim MacGregor Smith for teaching me Multi Criteria Decision Making and Stochastic Processes, my friends and colleagues, Ze He for his helpful comments and support, Junghee Jo for creating the visualization tool used in this thesis and Jennifer Badylak-Reals for helping me code the raw data for the thesis.

Special thanks go out to my parents for their moral and financial support and for their continued belief in me, and to Ben and Larissa, who have helped me whenever I needed them, and for making it possible for me to do the undoable.

# ABSTRACT

THE PROCESS BY WHICH PHYSICIANS EXTRACT INFORMATION FROM ELECTRONIC PROGRESS NOTES DURING HANDOFFS

SEPTEMBER 2012

BRIAN AMSTER, M.S.I.E.O.R. UNIVERSITY OF MASSACHUSETTS

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Directed by: Professor Jenna Marquard

A handoff requires that the responsibility for patient patient’s care is transferred from one healthcare professional to another. The goals of this research were to identify, evaluate, and use analytical methods to describe how physicians (n=10) extracted information from electronic progress notes, one important source of information used during handoffs. Participants also verbally summarized the notes as they would during handoffs. Six methods were used to analyze how participants read progress notes, each uniquely contributing to our understanding of physicians’ visual attention patterns during this process. The participants focused their visual attention on the Impression and Plan section of the progress notes in that over 60% of the participants’ total time was spent reading that section. Physicians could miss an error or critical piece of information if the information is not located in the Impression and Plan. The importance given by the participants to the Impression and Plan section was confirmed in that the majority of participants’ verbal handoff content focused primarily on information that could be found in the Impression and Plan. Participants relied on the Medication Profile section quite heavily if it was present in the progress note.

We determined that if the participant was currently reading in one section (s)he most likely would transition his/her visual attention to the physically closest section in the note, meaning the format of progress notes may dictate how notes are read. We determined what the most likely paths were through the progress notes, which could be a first step in reordering of the progress note for evaluation in future studies.

Participants' responses to debriefing questions suggested that they were aware of their reliance on the Impression and Plan, but that they thought the way they read notes is context-specific, depending on factors such as their use of the note and the reputation of the author of the note. These findings suggest a need for more research that evaluates how different note structures and content affect how physicians and other health providers extract and use information in varied clinical contexts.

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# CHAPTER 1

# INTRODUCTION

A handoff is an event where the responsibility for the care of a patient is transferred from one healthcare professional to another. The goals of this research are to:

- Identify and evaluate methods to analyze how physicians visually navigate through electronic progress notes, one type of document used during a handoff.
- Use these methods to compare physicians' visual attention patterns with areas of the note that physicians summarize during a simulated handoff.

A handoff requires that important, sometimes critical information about the patient is exchanged verbally or in writing between one healthcare professional to another in an efficient and effective manner. One source of information available to physicians is the written progress note. As electronic health records (EHRs) become more commonplace, progress notes are more often produced and read using electronic media. Despite their potential benefits, EHRs are known to pose significant usability challenges for healthcare professionals, potentially causing serious medical errors [1]. Handoffs are additionally challenging because healthcare professionals must decide which information in the EHR is important and which information is irrelevant, and communicate this information accurately and concisely during the patient handoff. In some cases, the parties communicate too much information while in other cases they share too little [2].

This work will provide fundamental information about what methods can be useful for analyzing how physicians extract information from electronic progress notes, as well as describing how actual physicians conduct this process. In support of this goal I will review two key bodies of literature which will provide information about:

1. The handoff process,
2. Current approaches to studying healthcare providers' interactions with EHRs, or the "usability" of EHRs.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Handoffs

A handoff is defined as a change in responsibility of care between one healthcare professional and another [2, 3]. A similar term, “sign-out” refers to the process in which information about a patient is transferred between caregivers – usually through written and/or verbal communication [2, 3]. In this study, we are using the term handoff as a more general term which includes the term sign out.

The Joint Commission on accreditation of healthcare organizations (JCAHO), a nonprofit organization that accredits and certifies healthcare organizations and programs in the United States, collects data on adverse events and near-misses which can be directly linked to communication problems, including communication during handoffs [4]. According to their data, communication issues were the cause of almost 70% of adverse events and near-misses in hospitals and healthcare institutions in the United States in 2006 [4].

Numerous studies have supported these data, suggesting that handoffs are key contributors to medical errors. A study done in 2007 in New Zealand found that of 60 resident physicians, 60.9% reported that they had encountered problems at least seven times in their most recent clinical rotation that they could directly attribute to poor handoffs [5]. In another study of stroke patients in 2007, of 183 adverse events, 86 were preventable, with 9 out of these 86 preventable adverse events attributed to communication/handoff errors between healthcare providers [6]. In 2005, a survey of 821 residents (physicians receiving specialized clinical training in a hospital) reported that adverse events were attributed to handoffs 15% of the time [7]. In a study of malpractice claims in 2006, 20% were associated with patient handoffs [8 ,9]. In a similar study in 2007 addressing malpractice in an emergency department, it was found that 24% malpractice claims were attributed to handoffs [8,10]. A 2003 study conducted in three teaching hospitals in Massachusetts found that "breakdowns in the accurate transfer of information, in particular during handoffs between personnel, were the second most common factor reported to contribute to error"[11]. In the Agency for Healthcare Research and Quality 2008 survey conducted in three teaching hospitals in Massachusetts, about half (51%) of the 160,176 hospital staff respondents reported that important patient care information was lost during handoffs [8,12].

Handoffs are challenging to conduct because it is difficult for healthcare professionals to know which information is important to communicate and which information is unnecessary and can be omitted. Trying to communicate too much information can cause the receiving healthcare provider to lose interest or not remember important details about the patient, while sharing too little information can cause the receiving healthcare professional to overlook information critical to the patient. This can lead the receiving healthcare professional to believe that the patient does not need the required level of attention when in fact, the proper standard of care requires more intense supervision of the patient [2].

The time it takes to conduct handoffs can be quite demanding [14]. For example, if each handoff takes five minutes, and handoffs are carried out at the beginning and at the end of an eight-hour shift, with a healthcare professional overseeing the care of twelve patients, then each handoff takes one hour. One handoff at the beginning, and one handoff at the end of a shift takes two hours, which means that that handoffs can consume up to 25% of total shift time [2,14].

Knowing what to communicate can also be influenced by the documents and record systems that healthcare professionals use during handoffs [2]. One type of document used in handoffs is the progress note [13]. Progress notes are written daily during a patient's hospital stay and are updated every time there is a change in the patient's status. These notes are used to keep track of the current status of a patient, and to communicate up-to-date assessments and care plans.

As electronic progress notes become more common, it is important to consider how the format and content of electronic notes might impact information retrieval. For example, it is not known how the organization and presentation of patient information in the note might impact physicians' abilities to sift through the document to find clinically useful information. While it is possible that progress notes and other documents can help organize information for handoffs and serve as a memory aids, there is also ample evidence that electronic documents can also produce negative effects by increasing professionals' cognitive loads [2,15].

### 2.2 Usability of Electronic Health Records (EHR)

The International Organization for Standardizations defines usability as (ISO 9241-11) "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [16]. Specific to healthcare, the Healthcare Information and Management Systems Society (HIMSS) defines usability as "the effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment. In essence, a system with good usability is easy to use and effective. It is intuitive, forgiving of mistakes, and it allows one to perform necessary tasks quickly, efficiently and with a minimum of mental effort" [1].

According to the 2003 Institute of Medicine (IOM) report, an EHR is able to collect electronic health information across time, provide immediate electronic access to the information by authorized users, provide knowledge and decision support, and support efficient healthcare delivery [17,18]. If EHRs are to effectively support user cognition during information-intensive tasks such as handoffs, EHR designers must pay careful attention to aspects of the user interface such as the amount of information, or the density of information, displayed on the computer screen [1]. When a great deal of information may be relevant to the user it can be very enticing for designers to put as much information on the computer screen as possible; however, visual search times and user errors increase in proportion to information density [1]. Many aspects of the user interface contribute to visual density; they include character count, screen resolution, font, font size and information grouping techniques [1].

Unfortunately, software developers frequently do not pay attention to relevant user characteristics, user tasks, user preferences, and usability issues, which can result in software that decreases productivity or is simply not usable [19]. While not specific to healthcare, The US General Accounting Office, a major supporter of software engineering, found that 98% of software designed for the US government was 'unusable as delivered' [19]. According to Zhang et. al, "Designing and implementing a health information system is not so much an IT project as a human project about human-centered computing such as usability, workflow, organizational change, medical error, and process reengineering" [20].

Different studies have used varied approaches to analyze the usability of EHRs. Zhang et. al used an approach called UFuRT---User Analysis, Functional Analysis, Representational Analysis and Task Analysis to analyze the usability of the U.S. military EHR system, called AHLTA [18]. UFuRT is a systematic methodology developed for the usability evaluation of information systems in the healthcare industry; it provides a conceptual framework based on work-centered principles. User analysis, for instance, identifies users' characteristics including their ages, educational backgrounds, expertise and skills [18,21,22].

Zhang et. al created a system hierarchy to represent each item on the AHLTA user interface to uniquely identify interface components. Each interface item in the hierarchy was classified as either an object or an operation. No actions or activities could be performed on objects. Operations on the other hand were items where actions or activities could be conducted. An example given in Zhang et. al's article was that in the software they were using a section called "Diagnosis" could only display information and therefore, was classified as an object. A section called "Priority" had up and down arrows which could be used to change information, specifically the priority of each diagnosis, and therefore this section was classified as an operation. Interface items classified as operations were then classified as either domain or overhead functions. A domain function was specific to the healthcare domain. The overhead functions were related to the operation of the user interface instead of the task [18]. Zhang et. al concluded that the usability of an interface may improve by minimizing the number of overhead functions, and that overhead functions are likely to result in unnecessary actions by the users [18].

In another study, the usability of AHLTA was analyzed using an approach called GOMS (Goals, Operators, Methods, and Selection rules), a usability technique that can identify lower level perceptual motor issues, quantify the complexity and efficiency of an interface, and evaluate the interface as a whole. Sitwell et. al first used GOMS to identify all of the sub-tasks of a given task and to classify them into mental or physical operators, and then used execution time calculations using a keystroke level model (KLM) to estimate the time required to accomplish each of the tasks [23].

In a study by Zheng et. al in 2009, user interactions with an EHR were analyzed by uncovering hidden navigational patterns in the EHR usage data. They created a mock up EHR which captured comprehensive user interface (UI) interaction events by recording time-stamps and the locations of computer mouse clicks used by the clinical staff that took part in the study. Zheng et. al then used sequential pattern analysis (SPA) and first-order Markov chain models to uncover recurring UI navigational patterns [24].

In a more recent study about Health IT implementations conducted in 2010, Zheng et. al presented new analytical methods consisting of workflow fragmentation assessments, pattern recognition, and data visualization, which they used to uncover hidden regularities embedded in the flow of work. They proposed a new workflow quantifier which they call average continuous time (ACT) to assess the magnitude of workflow fragmentation. ACT is the average amount of time continuously spent performing a single clinical activity. Workflow fragmentation is defined as the rate at which clinicians switch between tasks. The shorter ACT spent on performing a single task, the higher frequency of task switching [25]. Workflow fragmentation is potentially important because it has been shown that frequent task switching is often related to increased mental burden [25, 26]. To uncover workflow patterns from time-stamped Time and Motion data, Zheng et. al use two pattern recognition techniques: consecutive sequential pattern analysis (CSPA) and transition probability analysis (TPA). CSPA is the same as SPA used in Zheng et. al 2009 study. The TPA computes the probabilities of transitioning among pairs of tasks [25].

Data visualization provide a means for transforming large quantities of numeric or textual data into graphical formats so that it can be more easily understood [25, 30]. In the 2010 study by Zheng et. al, they used three visualization techniques:

1. A ‘timeline belt’ diagram using distinct colors to delineate the sequential execution of a series of clinical tasks, useful for visually understanding the sequential order and duration of each task [25].
2. A network plot exhibiting the transition frequencies between pairs of tasks to understand the temporal relations among different activities and the pre- and post-test (e.g., before and after technology implementation) data [25].
3. A heat map visualization displaying transition probabilities between different tasks using varied density of colors. In these heat maps, higher transition probabilities and significant pre and post test differences can be recognized [25].

While this study does not directly asses an EHR like Zheng et. al’s 2009 study it shows the breadth of this type of analysis. The research in this thesis extends the use of some of these methods to analyze health care providers’ visual attention patterns while reading information in EHRs.

# CHAPTER 3

# METHODS

## 3.1 Goals

Baystate Medical Center (BMC), in Springfield, Massachusetts is an academic, research, and teaching hospital that serves as the western campus of Tufts University School of Medicine. Physicians (n=10) at Baystate Medical Center were recruited to participate in this study. Physicians were included if they had an appointment in the Department of Medicine or Pediatrics as a faculty hospitalist. Resident physicians and nurse practitioners were not included in this study. Physicians were approached through an e-mail describing the study with instructions to respond if they were interested in taking part.

The three progress notes were all taken from the second hospital day of an adult medicine service at Baystate Medical Center. The patient progress notes were reviewed in the EHR at Baystate by the Associate Medical Director of Clinical & Quality Informatics, and screen shots of the notes were taken (SnagIt by TechSmith**,** Okemos, MI, USA). Any confidential and protected health information contained in the screen shots was blocked. The edited screen shots were then copied and pasted into a Microsoft Word document. An example screen shot of a progress note is shown in Figure 1 (see Appendix A for the other two progress notes). Each progress note had the same structure, with the following general sections: Demographics, Overnight Events, Review of Systems, Review and Management, Vital Signs, Physical Examination, Results and Review, Medication Profile, and Impression and Plan.

# Figure 1: Progress Note 1

**Medical Progress Note**

Age: **80 years** Sex: **Male**
Associated Diagnoses: **None**
Author: **Igarashi MD, Satoko**

**Overnight Events & Current Issues**
no new problems. still short of breath.

**Review of Systems**
**Review of Systems**
Constitutional: no chills, no fever, no night sweats.
Respiratory: shortness of breath.
Cardiovascular: peripheral edema, chest pain, no orthopnea, no chest pressure, no palpitations.
Gastrointestinal: no abdominal pain, no nausea, no vomiting, no diarrhea, no constipation.

**Review / Management**
**DVT Prophylaxis**
Fully anticoagulated.
**Foley Catheter**
No.

**Physical Examination**
**Vital Signs**
Vitals : VITAL SIGNS SECTION.

| | | |
|---|---|---|
| 1/13/2010 12:27 | Systolic Blood Pressure | 118 mm Hg |
| | Diastolic Blood Pressure | 74 mm Hg |
| 1/13/2010 5:52 | Temperature | 98.1 DegF |
| | Pulse Rate | 71 bpm |
| | Respiratory Rate | 20 br/min |
| | Oxygen Saturation | 96 % |
| | Liters per Minute | 2 L/min |
| | Mode of Delivery (Oxygen) | Nasal cannula |

**General Appearance**
NAD.
**HEENT**
Moist mucous membranes.
**Respiratory**
Lungs: crackles, bilateral bases.
**Cardiac**
Cardiac: no M/G/R.
Rhythms: RRR.
**Abdomen/GI**
Abdomen: soft, non-tender, non-distended, bowel sounds.
**Extremities**
Extremities: no clubbing.
Edema: grade 3 .
**Neurologic**
Alert & oriented x 4 .

**Results Review**
**7 Day Results**
Results
Laboratory : LABORATORY

| | | |
|---|---|---|
| 1/13/2010 5:35 | WBC | 6.5 k/mm3 |
| | Hgb | 14.0 Gm/dL |
| | Platelet Count | 163 k/mm3 |
| | **INR** | **1.7 H** |
| | **Potassium** | **3.2 mmol/L L** |

**Medication Profile**
MED PROFILE
Medication Orders (selected)
Furosemide (Furosemide Inj), 40 mg, Injection, IV Push Slowly, 3 times a day, Routine, 01/12/10 8:00:00, Refer to reference text / patient insert for additional medication information
Aspirin (Aspirin Tablet), 81 mg, EC Tablet, By Mouth, Daily, Routine, 01/12/10 8:00:00
Simvastatin (Simvastatin Tablet), 40 mg, Tablet, By Mouth, Daily at bedtime, Routine, 01/12/10 22:00:00
Carvedilol (Carvedilol Tablet), 12.5 mg, Tablet, By Mouth, 2 times a day, Routine, 01/13/10 11:29:00
Famotidine (Famotidine Tablet), 20 mg, Tablet, By Mouth, 2 times a day, Routine, 01/13/10 12:44:00
Docusate (Colace Capsule), 100 mg, Capsule, By Mouth, 2 times a day, Routine, 01/13/10 12:45:00
Warfarin (Coumadin Tablet), 5 mg, Tablet, By Mouth, Once, Routine, 01/13/10 18:00:00, Stop date 01/13/10 18:00:00, Refer to reference text / patient insert for additional medication information
Intermittent Orders
Levofloxacin (LEVOFLOXACIN 750mg/150 mL D5%W), 750 mg, IVPB, Premix, Every 24 hours for 5 days, Routine, 01/13/10 7:00:00, Stop date 01/17/10 7:00:00, Refer to reference text / patient insert for additional medication information

**Impression and Plan**
Advanced Directive
Full
80 yo gentleman with a history of afib, hodgkin's lymphoma 20 years ago, prostate ca, and congestive heart failure who is admitted for pneumonia and acute congestive heart failure.

1. Community-acquired pneumonia: The patient with a new left lower lobe infiltrate. continue treatment with levaquin.

.

2. Acute CHF exacerbation. The patient with a small bilateral effusion on the x-ray, JVD, gallops, bilateral leg edema. echocardiogram confrims decrease in systolic function and diastolic dysfunction. He is being followed by PVC ( ) who agrees with the change to coreg. dose increased today. his propafenone has been discontinued. He will continue lasix; he is negative 600 over the past 24 hours and his weight is stable. follow electrolytes and renal function. As his potassium is falling, I will add supplementation.

3. History of atrial fibrillation. Currently is in sinus. INR 1.7 today, will dose coumadin x1. The patient takes Coumadin 2.5 mg every Sunday, Thursday and Saturday and 5 mg Monday, Tuesday, Wednesday and Friday. I will continue Coumadin therapy once INR is available.

4. bowel prophylaxis: colace, famotidine.

Table 1 depicts the different diagnoses for each note. The contents of the sections included in each note are described in Table 2 and were consistent across all notes. The notes only varied based on what patient-specific information was reflected in each section.

**Table 1: Diagnostic content of notes**

| Diagnosis/Condition | Note 1 | Note 2 | Note 3 |
|---|---|---|---|
| Congestive Heart Failure | X | X | X |
| Dyspnea | X | X | |
| Chest pain | X | | X |
| Atrial Fibrillation | X | | X |
| Pneumonia | X | | |
| Hypokalemia | X | | |
| Diabetes | | X | X |
| Hypertension | | X | X |
| Kidney Disease | | X | |
| Depression | | X | |
| Constipation | | | X |
| Hyperkalemia | | | X |

**Table 2: Content and data source for note section**

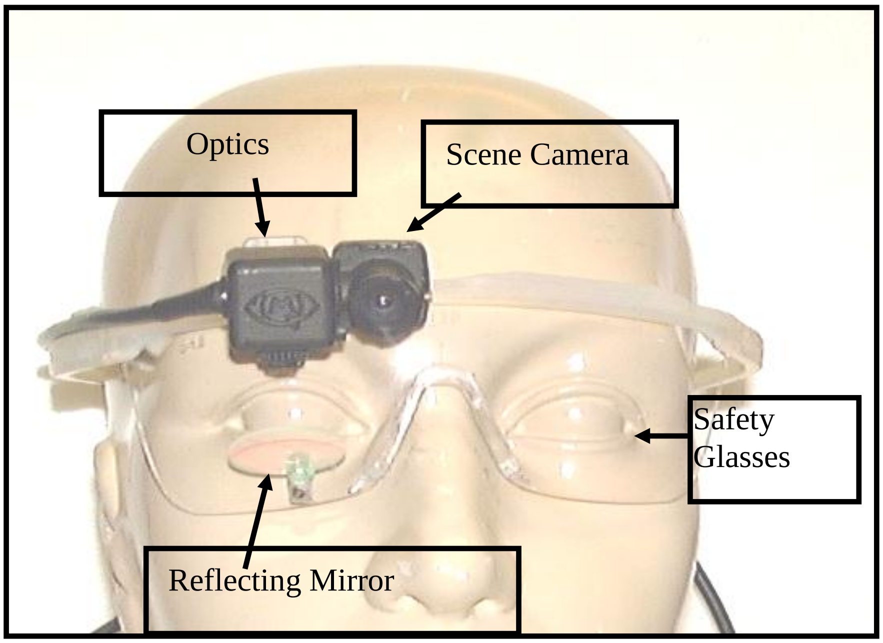
| Section | Description of content | Data Source |
|---|---|---|
| Demographics | Age and gender | Imported from database |
| Overnight Events | Description of clinical events over the past 12-24 hours. | Narrative text |
| Review of Systems | Patient symptoms by body system (e.g. constitutional, respiratory, cardiovascular, etc.) | Structured data entry |
| Review and Management | Hospital quality & safety measures (e.g. DVT prophylaxis) | Structured data entry |
| Vital Signs | Recorded patient data (e.g. body temperature, heart rate, blood pressure, etc.) | Imported from database |
| Physical Exam | Record of a physician's physical exam findings. | Structured data entry |
| Results and Review | Laboratory results | Imported from database |
| Medication Profile | List of the medications a patient is receiving during the hospital admission. | Imported from database |
| Impression and Plan | Summary of care about the patient including a synopsis of problems, plans for treatment and goals for hospital discharge. | Narrative text |

In all three trials, participant physicians wore an eye tracking device while reading and performing the handoff process. The eye tracker, shown in Figure 2, is an ASL Mobile Eye device (Applied Science Laboratories, Bedford, MA). The eye tracking device weighs 76 grams, which includes a scene camera, optics, and reflecting mirror which is mounted on safety glasses. The eye tracker records both video and audio tracks. Calibration of the eye tracker for each participant was done using the automatic calibration function provided by the ASL Mobile Eye software. Participants looked at approximately nine specific reference points (Xs) on the computer monitor that they used to read the different progress notes. Participants were asked to look at the center of each X, as the X moved to specific locations on the monitor. The ASL Mobile Eye software program overlaid crosshairs at the exact locations on the video where the participants were fixating on throughout the trial.

The eye tracking device is accurate to within 0.5 degrees of visual angle, with a resolution of 0.10 degrees of visual angle; the visual range of the eye tacking device is 50 degrees horizontally and 40 degrees vertically with respect to the head. The eye tracking device‘s scene camera records a video of the area in front of the wearer and uses pupil–corneal reflection to measure the position of the eye – sampled at 25 Hz.

In 1980, Just and Carpenter published an article called *A Theory of Reading: From Eye Fixations to Comprehension.* It provides an important assumption that the eye remains fixated on a word as long as the word is being processed; this is known as the mind eye assumption [28]. This assumption has later evolved into the mind eye hypothesis which suggests that individuals are usually thinking about what they are looking at. People do not always completely understand or engage with information, but if they are looking at something, it may be assumed that they are paying attention to, or thinking about what they are looking at, especially when they are concentrating on a particular task [29]. I will accept this hypothesis to be true for this study.

**Figure 2: Mobile Eye Tracker**




To avoid influencing how participants directed their attention when reading the note, they were instructed to read each note at their own pace with no time limit applied. After reading each note, participants dictated a verbal handoff as if they were transitioning care to another hospitalist. We used the verbal handoff as a cognitive anchor to help us understand which portions of the notes the participants felt were most important. After reading and conducting handoffs for the three notes, we asked each participants debriefing questions including: 1) Were the notes believable?; 2) What strategies do you typically use to read notes?; and 3) How does context influence how you approach reading a note? The dictations and interviews were recorded, transcribed and analyzed for content. Participants' ages, genders, residency types (medicine or combined medicine/pediatrics) and years since completing residency were also recorded.

This study can represent two plausible scenarios:

1. A physician with many patients reading a progress note and verbally summarizing it to an incoming physician.
2. An incoming physician reading a progress note from an outgoing physician without the outgoing physician being present.

The second scenario may be more in line with how the study was conducted. The participants did not write the progress notes and they did not have any more information than what was in the progress notes. The second scenario described above is particularly interesting because it takes the perspective of the physician taking over the responsibility for the patient. My search of the literature suggests that this viewpoint has never been addressed before.

**3.2 Video Coding Policy**

Each progress note was divided into nine physical sections for analysis, each section representing a different section of the progress note. Figure 3 shows how these sections were defined. Whenever the crosshairs on the eye tracker video landed within one of the nine predefined sections, I recorded when and how long the crosshairs landed within the section of the progress notes uising ASL Results Pro (ASL software, Bedford MA).

## Figure 3: Progress note sections

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Edema: grade 3 .
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**7 Day Results**
Results
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**Impression and Plan**
Advanced Directive
Full
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1. Community-acquired pneumonia: The patient with a new left lower lobe infiltrate. continue treatment with levaquin.

2. Acute CHF exacerbation. The patient with a small bilateral effusion on the x-ray, JVD, gallops, bilateral leg edema. echocardiogram confrims decrease in systolic function and diastolic dysfunction. He is being followed by PVC ( ) who agrees with the change to coreg. dose increased today. his propafenone has been discontinued. He will continue lasix; he is negative 600 over the past 24 hours and his weight is stable. follow electrolytes and renal function. As his potassium is falling, I will add supplementation.

3. History of atrial fibrillation. Currently is in sinus. INR 1.7 today, will dose coumadin x1. The patient takes Coumadin 2.5 mg every Sunday, Thursday and Saturday and 5 mg Monday, Tuesday, Wednesday and Friday. I will continue Coumadin therapy once INR is available.

4. bowel prophylaxis: colace, famotidine.

1. Demographics
2. Overnight Events
3. Review of Systems
4. Review/Management
5. Vital Signs
6. Physical Examination
7. Results and Review
8. Medication Profile
9. Impression and Plan

A character count was also performed on each section of the three progress notes. Each letter was counted as well as white spaces between the words. The white spaces between the words were counted because they naturally added to the volume of the text. The larger the document or section is, the more it might capture a participant's attention [1].

### 3.3 Analysis Approach

Using the eye tracking data, I expanded on relevant usability analysis methods described in the literature review to analyze participants' visual attention patterns while conducting handoffs. The following section describes the type of analysis performed for this study

1. Glance Characteristics
    a. Average time (AT): to assess the magnitude of fragmentation in the participants' glances. The AT shows the average amount of time spent looking at each section of the progress notes.
    b. Descriptive graphs: The graphs will show scatter plots detailing the: 1) average glance durations in each section verses the respective character counts of the sections, 2) number of glances in each section versus the respective character counts of the sections, 3) number of glances in each section versus the average glance durations, and 4) the relationship between the durations of first and average subsequent glances in the sections.
    c. Timeline visualization: to understand what areas of the progress note the participants looked at and how long they are looked at particular section of the

note. The visualizations will show the sequence of glances in each section, and their durations, over the course of each trial.

2. Glance Patterns

    a. Transition probability analysis (TPA): to compute the probabilities of participants transitioning their glances between sections in the progress note. TPA will show the probabilities of transitioning glances among pairs of sections. In other words, if a participant is glancing at particular section, what are the probabilities that the participant transitions his/her glance to each other section? The results of the TPA analysis provide an overall probabilistic view of the sequential relations among glances in different sections [25].

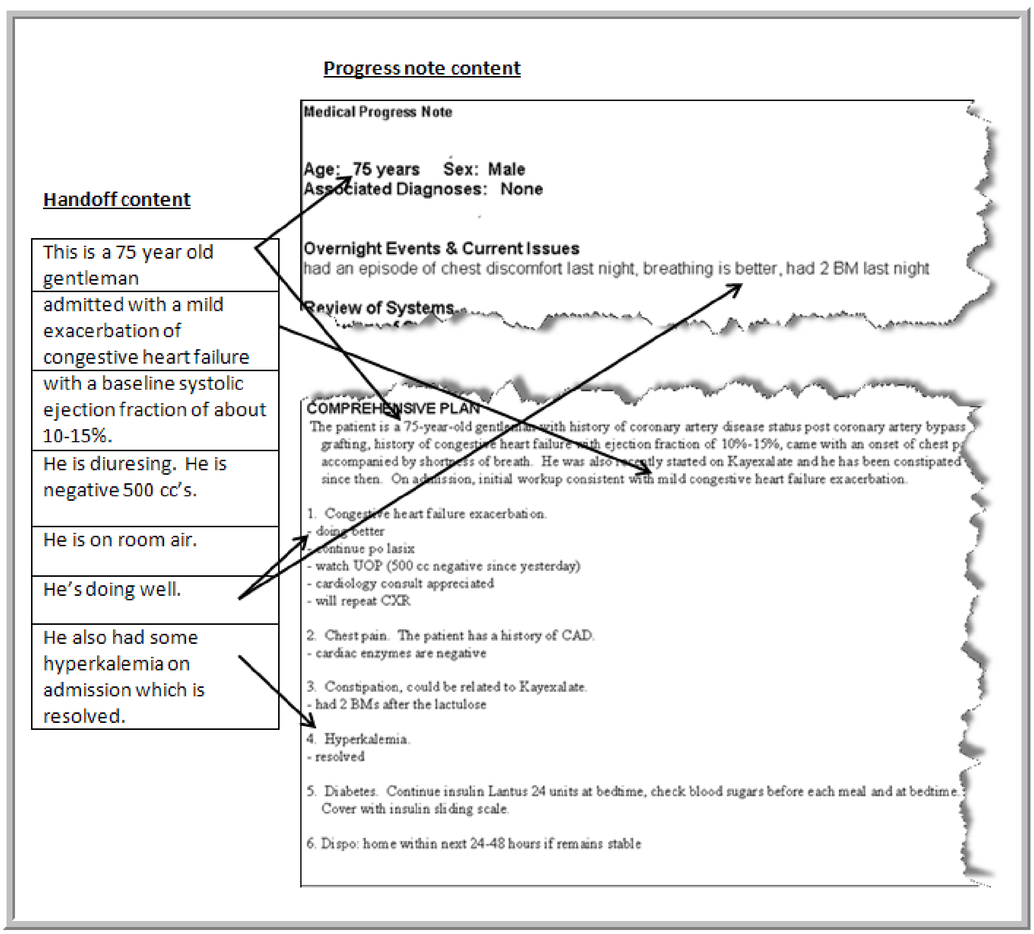
    b. Visualization of navigational pathways through the progress notes: to provide insights into the participants' navigation patterns through the progress notes. The visualizations will provide insights into the participant's patterns of glances through the progress note.

    c. Sequential pattern analysis (SPA) using first order Markov chain analysis: to find hidden navigational patterns that participants use while they are looking at a progress note [25]. First order Markov chain analysis will show participants' most likely sequences of glances between sections while reading through the progress note.

3. Verbal Analysis

    a. In a parallel study, we looked at what participants said during the verbal handoff. The verbal recordings of the handoffs were transcribed and assessed for content. The verbal content for each participant was then mapped to the nine predefined sections in the note. For example, if the participant said "*This is a 75 year old gentleman*" that content was mapped to the "Demographic" and "Impression and Plan" sections of a particular progress note, if both these sections included information about the age and gender of the patient. An example of this method is illustrated in Figure 4. "*This is a 75 year old gentleman*" has arrows to the Demographics section and the Impression and Plan section. In addition, we also assessed the word count of the verbal handoffs to understand the amount of information each participant conveyed [30] .

**Figure 4: Handoff content mapping**



# CHAPTER 4

# RESULTS

Ten participants took part in this study.

## 4.1 Glance Characteristics

### 4.1.1 Average Time (AT)

Table 3 depicts summary glance statistics for the 10 participants that participated in this study. The average duration for each glance is in seconds. The participants' average glance durations were longest in the Impression and Plan section, with the average duration being over 70 seconds for each of the three notes (over 60% of the time spent reading each of the three notes). In Note 1 the second longest average glance duration was in the Medication Profile section at 9.3% of the time spent reading the note. In Note 2, the participants spent about the same amount of time glancing in the Medication Profile and Results and Review sections at just over 13 seconds each (10.7% and 11.1% of the time spent reading the note, respectively). In Note 3, the second longest average glance duration was in the Results and Review section (8.8% of the time spent reading the note).

The average number of glances in each section can also be seen in Table 3. Similarly to the average glance duration, the Impression and Plan section was glanced at over 10 times on average for each note meaning that, on average, over 27% of glances were in this section for each of the three notes.

**Table 3: Summary glance statistics**

| | Progress note 1 | | | | Progress note 2 | | | | Progress note 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | Avg Dur-ation in Section | Avg % of Time Spent in Section | Avg # of Glances in Section | Avg % of Glances in Section | Avg Dur-ation in Section | Avg % of Time Spent in Section | Aveg # of Glances in Section | Avg % of Glances in Section | Avg Dur-ation in Section | Avg % of Time Spent in Section | Avg # of Glances in Section | Avg % of Glances in Section |
| Demographics | 1.6 | 1.5% | 2.7 | 6.1% | 1.9 | 1.5% | 3.4 | 8.8% | 1.7 | 1.6% | 2.9 | 7.6% |
| Overnight Events | 1.5 | 1.4% | 2.6 | 5.9% | 2.7 | 2.2% | 3.6 | 9.4% | 3.2 | 3.0% | 3.5 | 9.1% |
| Review of Systems | 6.3 | 5.7% | 5.2 | 11.8% | 3.3 | 2.7% | 3.9 | 10.1% | 1.7 | 1.7% | 2.7 | 7.0% |
| Review and Management | 1.4 | 1.2% | 1.9 | 4.3% | 1.4 | 1.2% | 1.8 | 4.7% | 1.2 | 1.2% | 1.6 | 4.2% |
| Vital Signs | 3.8 | 3.5% | 2.4 | 5.4% | 6.5 | 5.4% | 2.1 | 5.5% | 6.5 | 6.3% | 3.3 | 8.6% |
| Physical Exam | 6.6 | 6.0% | 3.8 | 8.6% | 6.0 | 5.0% | 3.0 | 7.8% | 3.4 | 3.3% | 3.1 | 8.1% |
| Results and Review | 2.9 | 2.6% | 5.0 | 11.3% | 13.4 | 11.1% | 3.8 | 9.9% | 9.1 | 8.8% | 5.4 | 14.1% |
| Medication Profile | 10.3 | 9.3% | 8.3 | 18.8% | 13.0 | 10.7% | 4.9 | 12.7% | 0.8 | 0.8% | 5.2 | 13.6% |
| Impression and Plan | 75.9 | 68.8% | 12.3 | 27.8% | 73.0 | 60.2% | 12.0 | 31.2% | 75.7 | 73.2% | 10.6 | 27.7% |
| Total | 110.2 | 100.0% | 44.2 | 100.0% | 121.2 | 100.0% | 38.5 | 100.0% | 103.4 | 100.0% | 38.3 | 100.0% |

Table 4 depicts the character counts for each section, as a percent of the total character count of the respective note. The percent of character count varies quite a bit across the three progress notes. In Note 1 the highest percent character counts are found in the Medication Profile and Impression and Plan sections. Note 2 had the highest percet character counts in the Results and Review and Medication Profile sections, and Note 3 had the highest percent character counts in the Vital Sign, Results and Review, and Impression and Plan sections. Table 4 also depicts the average amount of time spent in each section, in seconds, per character. On average physicians spent the most time per character on the Impression and Plan section, spending between 0.065 and 0.117 seconds on each character in that section.

**Table 4: Percent of total note character count and seconds per character count**

| Section | Progress note 1 | | Progress note 2 | | Progress note 3 | | |
|---|---|---|---|---|---|---|---|
| | % of total Char-acter Count | Avg Seconds per Char-acter | % of total Char-acter Count | Avg Seconds per Char-acter | % of total Char-acter Count | Avg Seconds per Char-acter | Average % of total Character Count |
| Demographics | 2% | 0.027 | 1% | 0.035 | 2% | 0.033 | 2% |
| Overnight Events | 2% | 0.021 | 2% | 0.031 | 4% | 0.027 | 3% |
| Review of Systems | 8% | 0.021 | 3% | 0.021 | 5% | 0.012 | 5% |
| Review and Management | 2% | 0.022 | 1% | 0.018 | 2% | 0.020 | 2% |
| Vital Signs | 9% | 0.013 | 8% | 0.015 | 19% | 0.012 | 12% |
| Physical Exam | 8% | 0.024 | 4% | 0.030 | 8% | 0.014 | 7% |
| Results and Review | 5% | 0.015 | 21% | 0.012 | 23% | 0.014 | 16% |
| Medication Profile | 32% | 0.009 | 49% | 0.005 | 2% | 0.016 | 28% |
| Impression and Plan | 33% | 0.065 | 12% | 0.117 | 36% | 0.073 | 27% |

### 4.1.2 Descriptive Graphs

Figures 5 and 6 depict the percent of glances in each section as compared to the average percent of time spent reading the section of the note. The Impression and Plan Section by far had the longest average percent of total time spent reading the note and average percent of total glance count in a section. Figure 5 shows which note each point in the graph represents and Figure 7 shows what data type each point represents. It can be seen in both graphs that the Impression and Plan is glanced at the most frequently and for the longest time. The Impression and plan is a narrative data type. The Overnight Events is the only other narrative data type but not much time and few glances were in that section.

**Figure 5: Average % glance duration vs. average % total glance count**

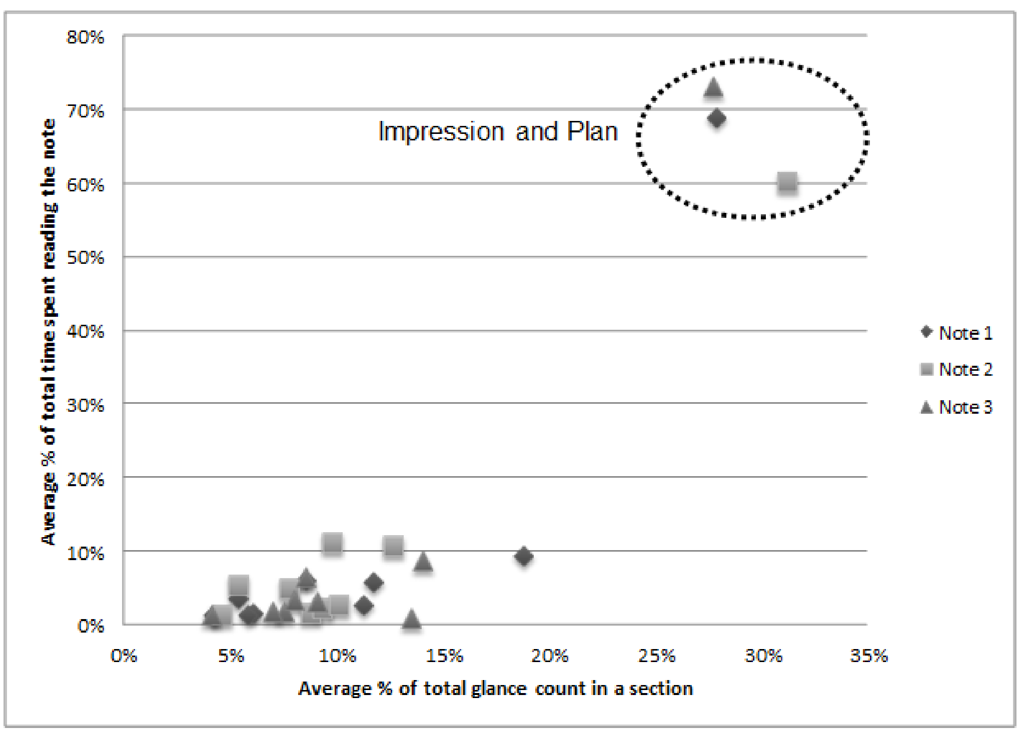


**Figure 6: Average % glance duration vs. average % total glance count by data type**

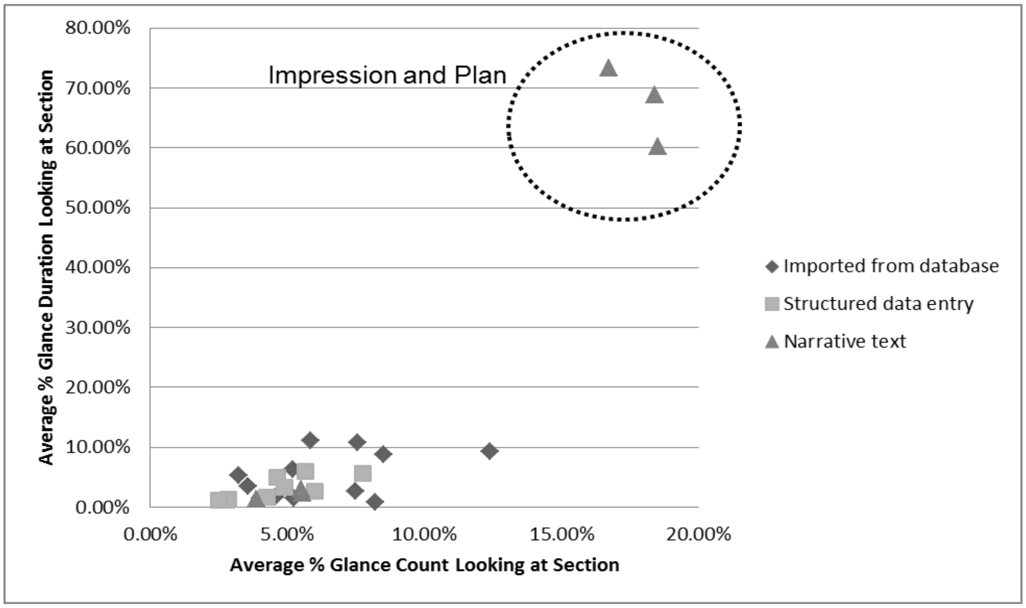



Figure 7 shows the average percent of participants' time spent reading each section compared to the percent character count of the text in the section. The two sections with the highest character counts were the Impression and Plan and Medication Profile sections for Note 1, the Medication Profile and Results and Review sections for Note 2 and the Results and Review and Impression and Plan sections for Note 3. The time spent in the Impression and Plan was fairly constant across trials though the volume of information (percent character count) varied, especially for Note 2. Conversely, regardless of the volume of the Medication Profile section, participants spent a relatively small fraction of their time glancing at this section.

**Figure 7. Average % glance duration vs. % character count**

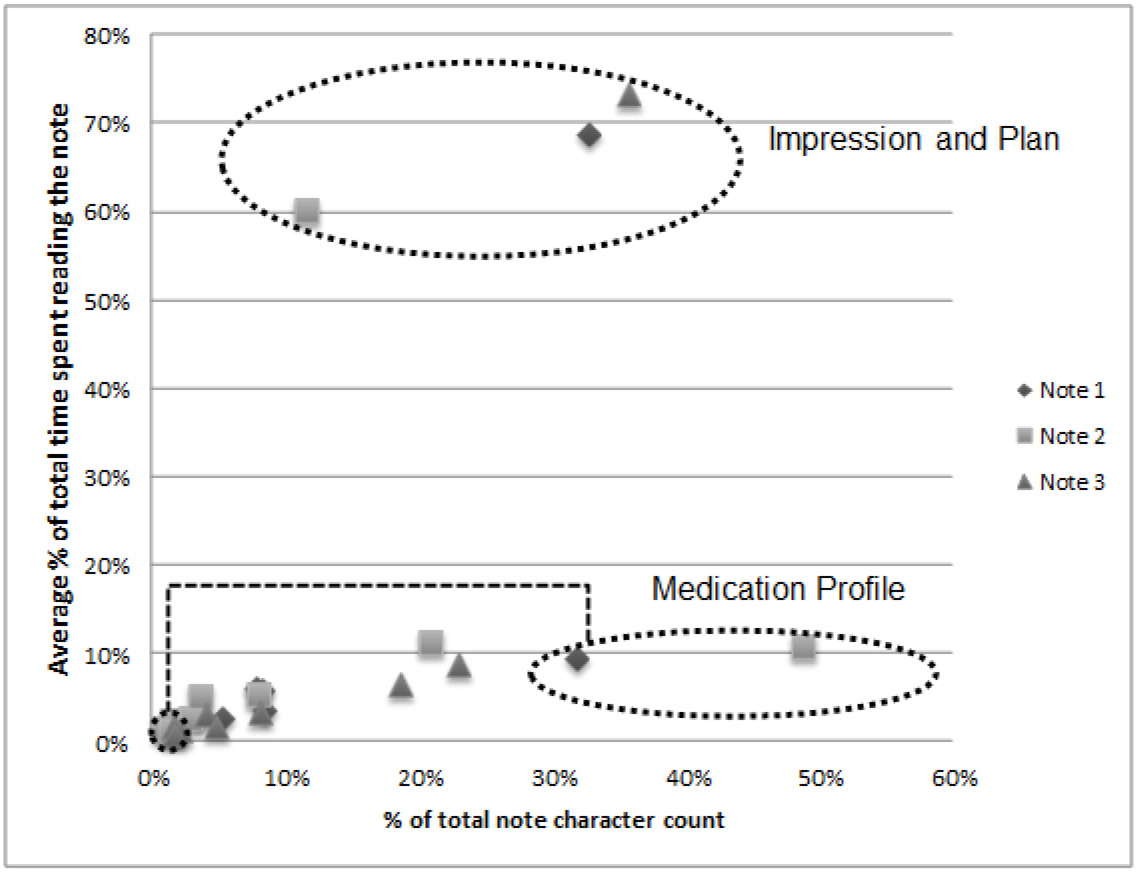



Figure 8 depicts the average percent of glances in each section compared to the percent of character count of each section. We see a similar pattern as in the Figure 10, though not as extreme, where participants had a greater number of glances in the Impression and Plan section regardless of the volume of text in the section.

**Figure 8. Average % glance count vs. % character count**

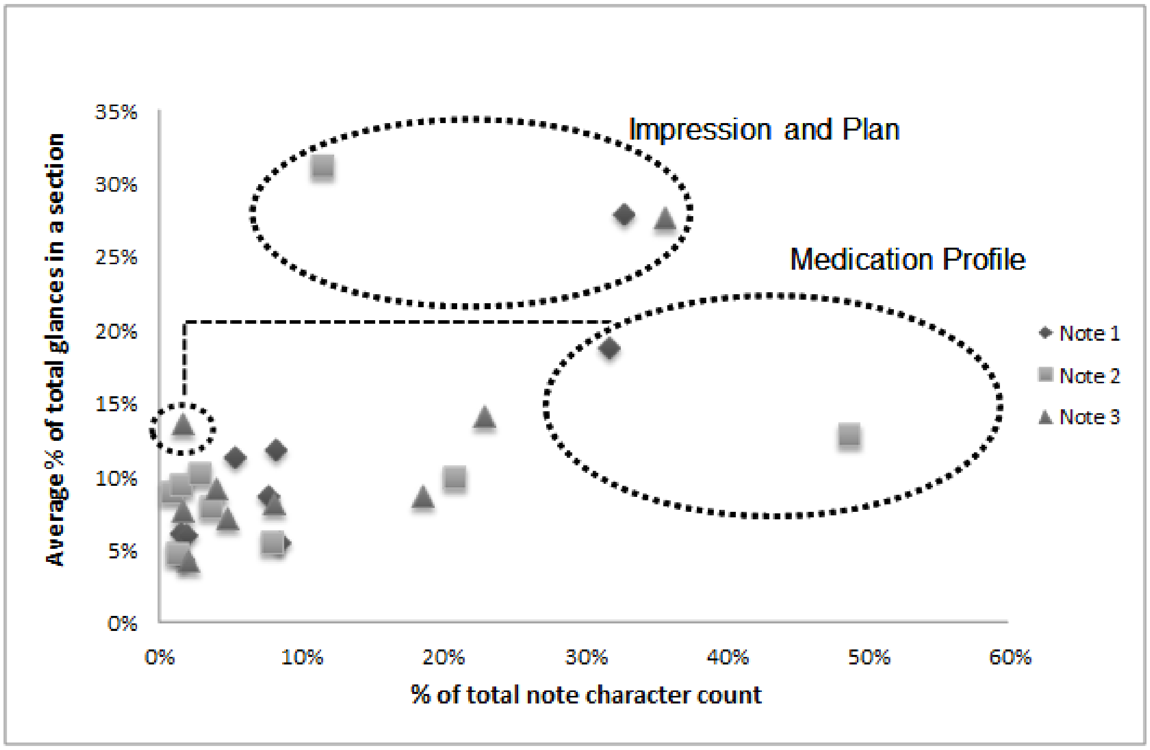



Figure 9 depics how many seconds the physicians spent reading each character, on average. This could indicate which sections they read more carefully. It is clear that the Impression and Plan section was read more slowly. In Note 2 the physicians still spent about the same amount of time in the Impression and Plan section as the other two notes even though it had 12% of the total character count and Notes 1 and 3 had over 30% of total character count.

**Figure 9: Average seconds per character**

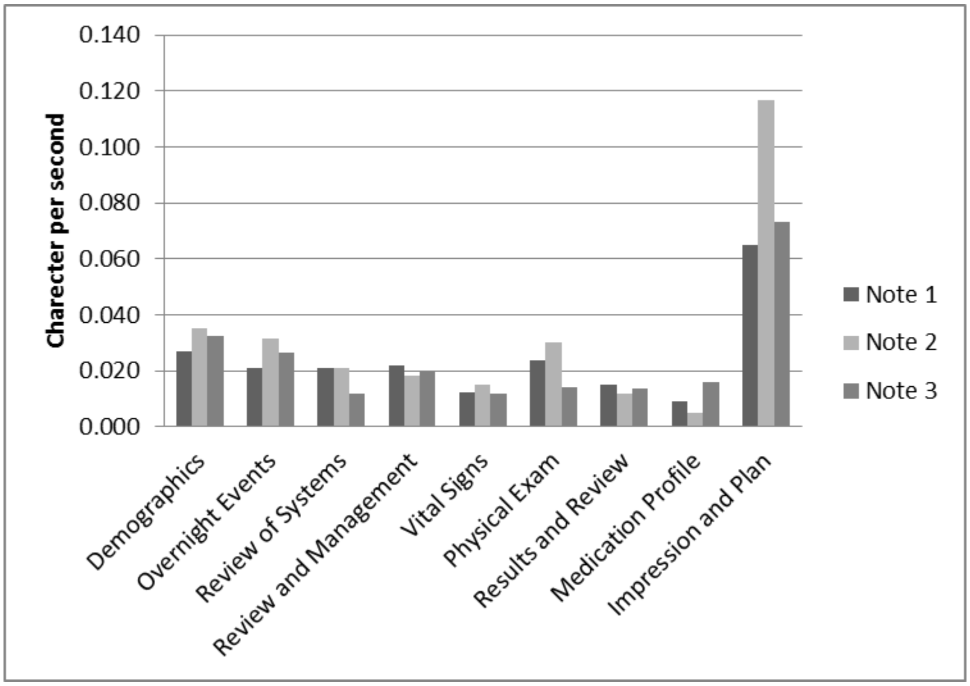
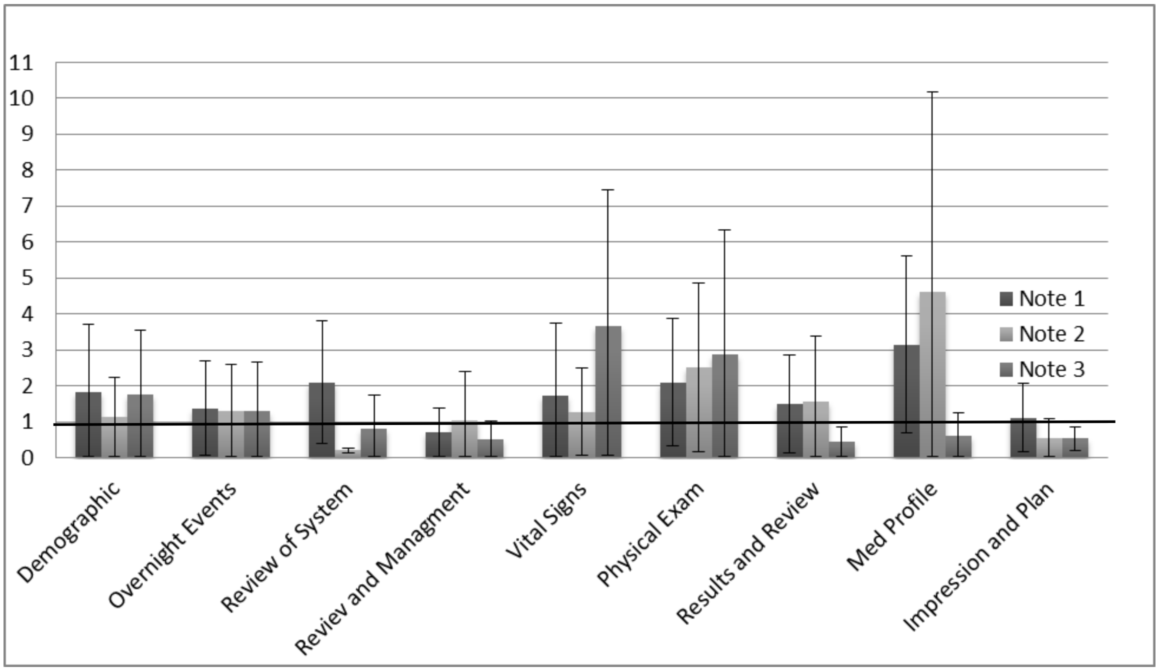



Figure 10 depicts the ratios between the participants' first glance durations and their average subsequent glance durations. If the ratio is less than one it means the first glance was shorter than the average of the subsequent glance durations. If the ratio is more than one, it means the first glance was longer than the average of the subsequent glance durations. If the ratio is one the first glance was the same duration as the average subsequent glance durations. Overall, the first glance durations were longer than the subsequent average glance durations. This means that the participants typically looked at a section longer the first time, then returned to the section for shorter periods of time. The error bars were calculated using 95% confidence intervals. The variation in the first and average subsequent glance durations is quite high.

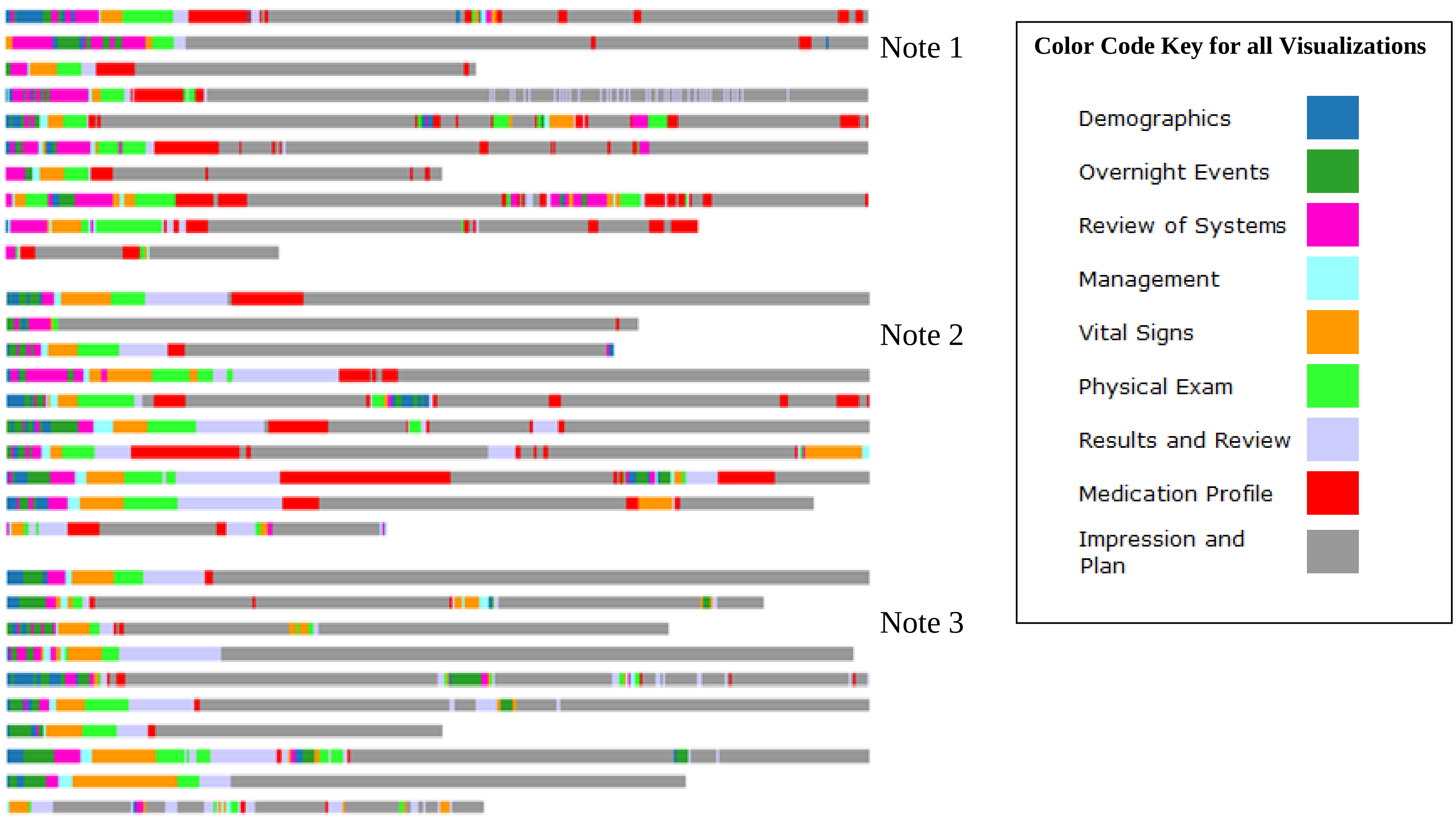
**Figure 10. Ratio of first glance duration / avg subsequent glance durations**




### 4.1.3 Timeline Visualization

Figure 11 depicts timeline visualizations for the three notes. The change in colors represents the change from glancing at one section on the progress note to another. Each line represents one of the ten participants in the study. The length of each color represents the duration of time spent in a particular section. This visualization provides an overall impression of what the flow of visual scanning was through each note. The visualization reinforces the findings in Table 3 (Summary Glance Statistics) in that the Impression and Plan section (dark grey) was glanced at for the longest periods of time, and Figure 10, in that the first glance durations tended to be longer than subsequent glance durations. We can also see that once the participant looked at the Impression and Plan section, (s)he spent a great deal of time in that section instead of switching frequently to other sections.

**Figure 11. Timeline visualization**



## 4.2 Glance Patterns

### 4.2.1 Transition Probability Analysis

We used transition probability analysis to describe the probabilities of the participants transitioning from one section to another. We calculated this by counting the number of transitions from a given section to each of the other sections, divided by the sum of all transitions from the first section to all the other sections. These transition probabilities are shown in Tables 5 through 7, with the left hand column being the starting section and the probabilities in the cells being the probabilities of transitioning to each other section. Blank cells represent probabilities of zero. Of note, these probabilities only account for direct transitions from one section to another; they do describe the likely path through the entire progress note. The entire path, section by section, will be mathematically described in the section 4.2.3, called Sequential Pattern Analysis.

**Table 5: Transition matrix for progress note 1**

| Section | | D | OE | RS | RM | VS | PE | RR | MP | IP |
|---|---|---|---|---|---|---|---|---|---|---|
| Demographics | D | | 0.30 | 0.39 | 0.13 | | | | 0.09 | 0.09 |
| Overnight Events | OE | 0.24 | | 0.64 | 0.12 | | | | | |
| Review of Systems | RS | 0.15 | 0.38 | | 0.18 | 0.15 | 0.08 | | 0.03 | 0.03 |
| Review and Management | RM | 0.06 | | 0.16 | | 0.66 | 0.06 | | | 0.06 |
| Vital Signs | VS | 0.09 | | 0.09 | 0.17 | | 0.50 | 0.05 | 0.05 | 0.05 |
| Physical Exam | PE | | 0.08 | 0.15 | 0.04 | 0.12 | | 0.46 | 0.15 | |
| Results and Review | RR | | | 0.02 | | | 0.02 | | 0.27 | 0.69 |
| Medication Profile | MP | 0.02 | | 0.02 | | | 0.14 | 0.14 | | 0.68 |
| Impression and Plan | IP | 0.02 | | | | | 0.01 | 0.49 | 0.48 | |

**Table 6: Transition matrix for progress note 2**

| Section | | D | OE | RS | RM | VS | PE | RR | MP | IP |
|---|---|---|---|---|---|---|---|---|---|---|
| Demographics | D | | 0.69 | 0.27 | | | | 0.04 | | |
| Overnight Events | OE | 0.47 | | 0.50 | 0.03 | | | | | |
| Review of Systems | RS | 0.16 | 0.35 | | 0.35 | 0.10 | | | | 0.03 |
| Review and Management | RM | 0.08 | | 0.08 | | 0.85 | | | | |
| Vital Signs | VS | | | 0.17 | 0.11 | | 0.67 | 0.06 | | |
| Physical Exam | PE | | | 0.10 | | 0.15 | 0 | 0.70 | | 0.05 |
| Results and Review | RR | | | | | | 0.32 | | 0.55 | 0.14 |
| Medication Profile | MP | | | | | 0.03 | 0.03 | 0.15 | | 0.79 |
| Impression and Plan | IP | | | 0.04 | 0.04 | | | 0.04 | 0.88 | |

**Table 7: Transition matrix for progress note 3**

| Section | | D | OE | RS | RM | VS | PE | RR | MP | IP |
|---|---|---|---|---|---|---|---|---|---|---|
| Demographics | D | | 0.75 | 0.25 | | | | | | |
| Overnight Events | OE | 0.33 | | 0.44 | 0.04 | 0.11 | | 0.08 | | |
| Review of Systems | RS | 0.13 | 0.29 | | 0.29 | 0.29 | | | | |
| Review and Management | RM | 0.06 | | 0.13 | | 0.62 | 0.19 | | | |
| Vital Signs | VS | 0.03 | 0.06 | 0.03 | 0.25 | | 0.44 | 0.06 | | 0.13 |
| Physical Exam | PE | | | | | 0.21 | | 0.75 | 0.04 | |
| Results and Review | RR | 0.02 | | | | 0.14 | 0.14 | | 0.21 | 0.49 |
| Medication Profile | MP | | | | | | | 0.24 | | 0.76 |
| Impression and Plan | IP | 0.04 | | | | 0.07 | 0.03 | 0.62 | 0.24 | |

The highest probability transitions from each section to the other sections can be seen in Table 8. For example, in Note 3, from the Review of Systems section (C) to the next section, there is a tie for highest probability between sections Review and Management (D), Overnight Events (B), and Vital Signs (E), each having a probability of 0.29.

Highest transition probabilities for each section occurring in all three progress notes are as follows:

- Review of Systems (C) →Overnight events (B),
- Review and Management (D) →Vital Signs (E),
- Vital Signs (E) →Physical Exam (F),
- Physical Exam (F) →Results and Review (G),
- Medication Profile (H) →Impression and Plan (I),

Highest transition probabilities for each section occurring in in 2 of the 3 progress notes are as follows:

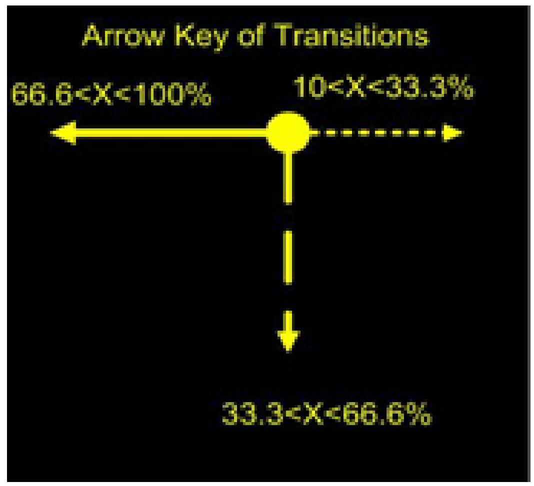
- Demographics (A) →Overnight Events (B) in Notes 2 and 3,
- Overnight Events (B) →Review of Systems (C) in Notes 1 and 3,
- Review of Systems (C) →Review and Management (D) in Notes 2 and 3,
- Results and Review (G) →Impression and Plan (I) in Notes 1 and 3,
- And lastly Impression and Plan (I)→Medication Profile (G) in Notes 1 and 2.

**Table 8: Highest transition probabilities for each sections in the three notes.**

| | | Note 1 | | Note 2 | | Note 3 | |
|---|---|---|---|---|---|---|---|
| Section | Key | Transi-tion | Prob-ability | Transi-tion | Prob-ability | Transi-tion | Prob-ability |
| Demographics | A | A---->C | 0.39 | A---->B | 0.69 | A---->B | 0.75 |
| Overnight Events | B | B---->C | 0.64 | B---->A | 0.47 | B---->C | 0.33 |
| Review of Systems | C | C---->B | 0.38 | C---->B<br>C---->D | 0.35 | C---->B<br>C---->D<br>C---->E | 0.29 |
| Review and Management | D | D---->E | 0.66 | D---->E | 0.85 | D---->E | 0.62 |
| Vital Signs | E | E---->F | 0.5 | E---->F | 0.67 | E---->F | 0.44 |
| Physical Exam | F | F---->G | 0.46 | F---->G | 0.7 | F---->G | 0.75 |
| Results and Review | G | G---->I | 0.69 | G--->H | 0.55 | G---->I | 0.49 |
| Medication Profile | H | H---->I | 0.68 | H---->I | 0.79 | H---->I | 0.76 |
| Impression and Plan | I | I---->H | 0.49 | I---->H | 0.88 | I---->G | 0.62 |

### 4.2.2 Visualization of Navigational Pathways

**Figure 12: Legend of transition arrows**




Figures 13 to 15 show how the participants visually navigated through the three notes, based on the transition probabilities shown in Tables 5 through 7. The short dashes in the visualizations represent transition probabilities between 10% and 33.3%, the long dashes represent transition probabilities between 33.3% and 66.6%, and the solid lines represent transition probabilities between 66.6% and 100%. Ten percent as a lower bound for showing transitions was chosen to make the visualizations more readable. The legend of transition arrows can be seen in Figure 12 to the right and on the right side of Figures 11 through 13. The circles are color coded and the *Color Code Key* is shown in Figure 12 next to the timeline visualization.

As an example of how to interpret the figures, in Figure 13 for Note 1, if the participant was currently reading the Demographics section (blue) the next transition was most likely to be the Review of Systems section (purple) which had a probability between 33.3% and 66.6% (long dashed line), participants were less likely to transition to the Overnight Events section (green) or the Review of Management section, both of which had probabilities between 10% and 33.3% (short dashed lines).

**Figure 13. Visualization of navigational pathways through progress note 1**

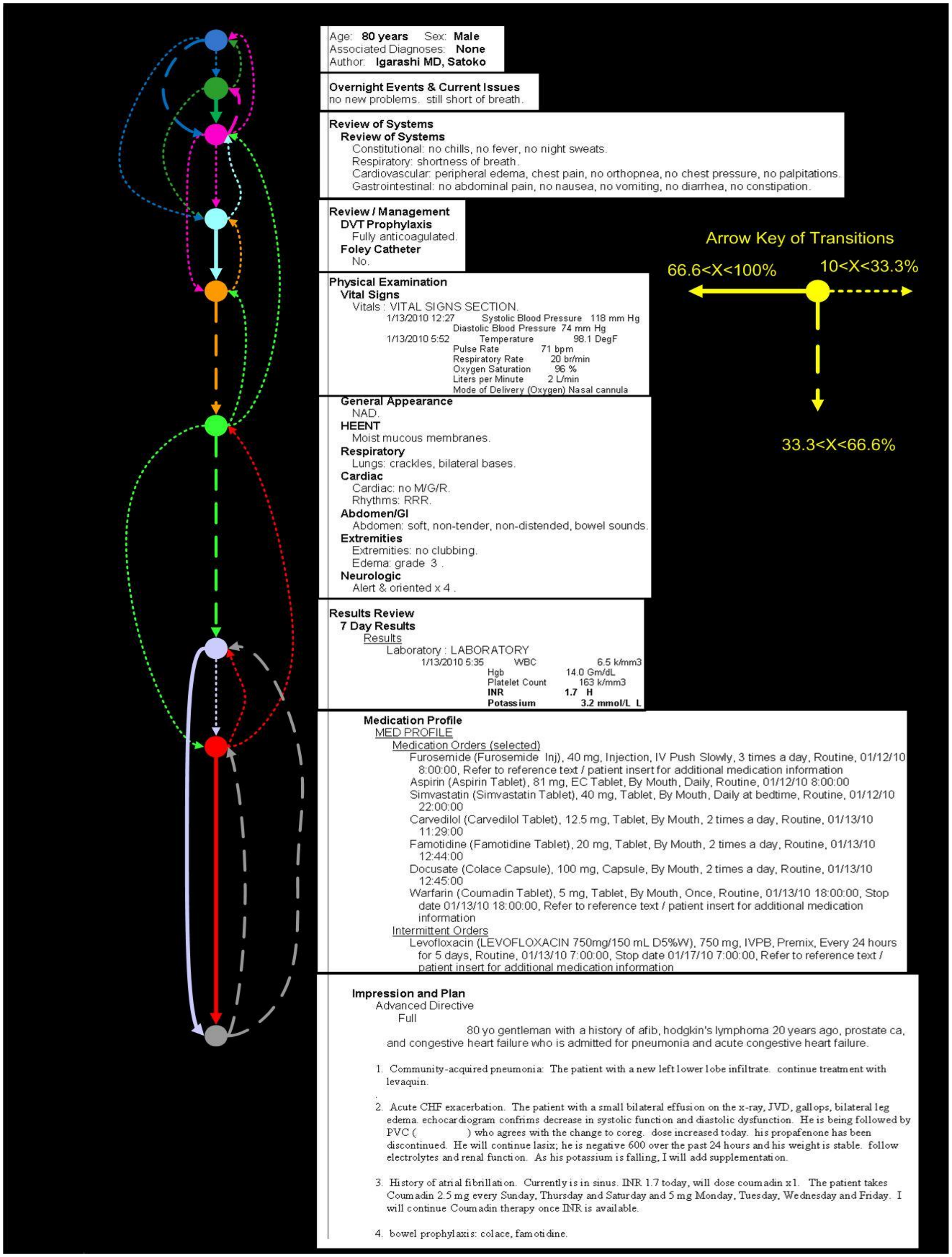
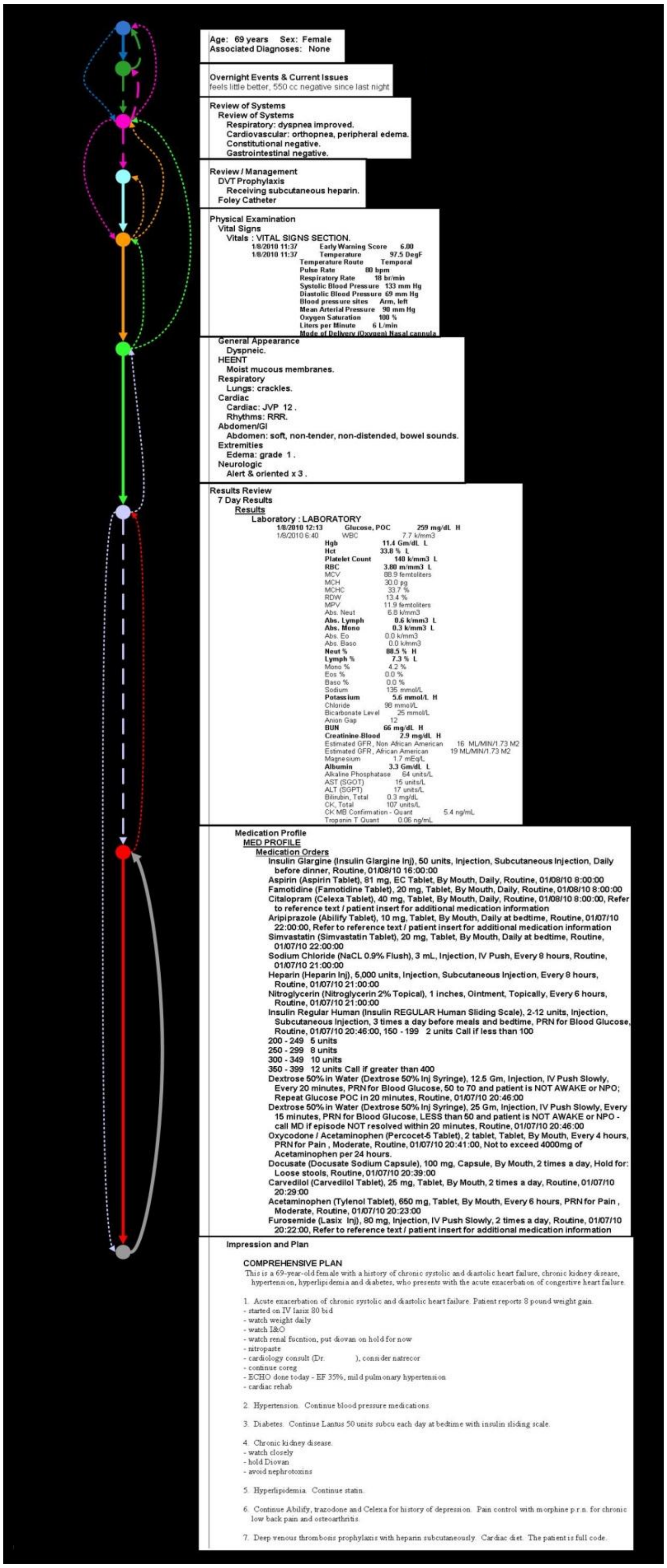
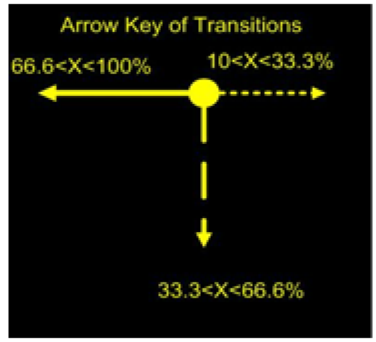
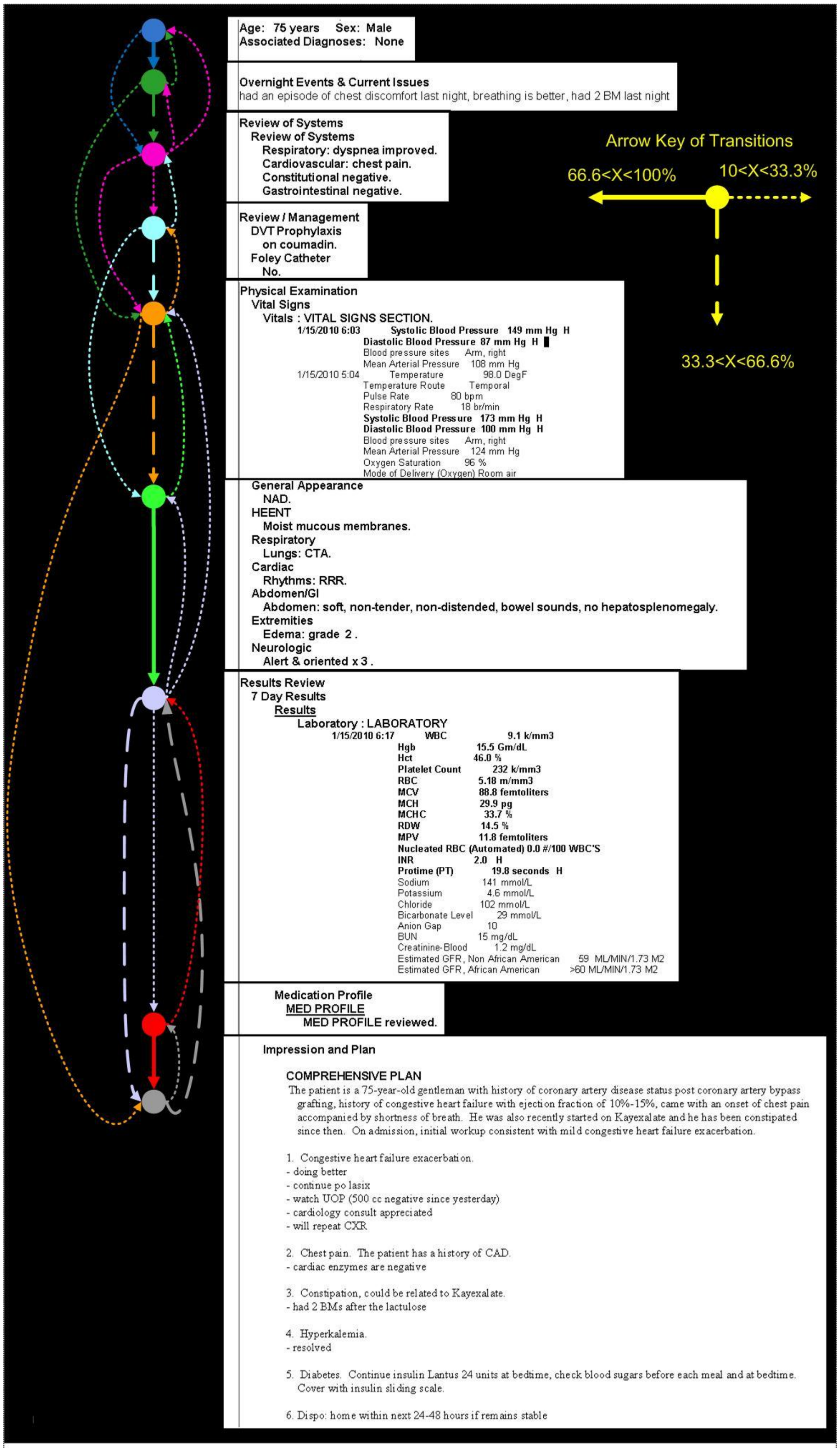


**Figure 14. Visualization of navigational pathways through progress note 2**



## Figure 15. Visualization of navigational pathways through progress note 3



### 4.2.3 Sequential Pattern Analysis

We used sequential pattern analysis to analyze complete sets of transitions across sections of the notes, for the 3 progress notes. Where the transition probability analysis depicted common pairwise transitions from one section to another, sequential pattern analysis enables us to compute a likely pathway for how the participants fully navigated through each of the progress notes.

In order to calculate the transition matrix for participants' complete pathway through each note, not just pariwise transitions as in 4.2.1, we used a stochastic process called first order Markov chain analyis. Tables 9 through 11 depict the results of this analysis for each of the three progress notes. Appendix B provides a detailed discription of how these calculations were done.

Table 9 shows the likely pathway through Note 1. Across the rows of this table, the bold numbers are the highest probability sections at a given time step . Table 9 shows that participants most likely started at the Demographics section (0.50), then transitioned between sections as follows: → Review of Systems →Vital Signs→Review of Systems→Impresion and Plan→Review of Systems→Impression and Plan→Medication Profile→Impression and Plan, then cycled between Impression and Plan and Medication Profile for the rest of the time steps.

**Table 9: First order Markov analysis for progress note 1**

| Time Step Number | Demo-graphics | Overnight Events | Review of Systems | Review and Manage-ment | Vital Signs | Physical Exam | Results and Review | Medi-cation Profile | Impres-sion and Plan |
|---|---|---|---|---|---|---|---|---|---|
| Start | **0.50** | 0.10 | 0.30 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.08 | 0.26 | **0.27** | 0.15 | 0.05 | 0.07 | 0.01 | 0.06 | 0.06 |
| 2 | 0.12 | 0.13 | 0.24 | 0.10 | **0.15** | 0.06 | 0.07 | 0.06 | 0.07 |
| 3 | 0.09 | 0.13 | **0.17** | 0.10 | 0.11 | 0.11 | 0.08 | 0.09 | 0.12 |
| 4 | 0.08 | 0.10 | 0.16 | 0.08 | 0.11 | 0.09 | 0.13 | 0.11 | **0.14** |
| 5 | 0.07 | 0.09 | **0.14** | 0.07 | 0.09 | 0.09 | 0.13 | 0.13 | 0.19 |
| 6 | 0.06 | 0.08 | 0.12 | 0.06 | 0.08 | 0.08 | 0.16 | 0.15 | **0.20** |
| 7 | 0.06 | 0.07 | 0.11 | 0.06 | 0.07 | 0.08 | 0.16 | **0.16** | 0.23 |
| 8 | 0.05 | 0.07 | 0.10 | 0.05 | 0.06 | 0.08 | 0.18 | 0.18 | **0.24** |
| 9 | 0.05 | 0.06 | 0.09 | 0.05 | 0.06 | 0.07 | 0.18 | **0.18** | 0.26 |
| 10 | 0.05 | 0.06 | 0.09 | 0.04 | 0.05 | 0.07 | 0.19 | 0.19 | **0.26** |
| 11 | 0.04 | 0.05 | 0.08 | 0.04 | 0.05 | 0.07 | 0.19 | **0.20** | 0.27 |
| 12 | 0.04 | 0.05 | 0.08 | 0.04 | 0.05 | 0.07 | 0.20 | 0.20 | **0.28** |

Table 10 shows the likely pathway through Note 2. Table 10 shows that participants again most likely started at the Demographics section (0.60), then transitioned between sections as follows: → Overnight Events→Review of Systems→Overnight Events→Review of Systems→Overnight Events→Review of Systems→Medication Profile→Overnight Events. At this point the likely path splits and the next sequence can be Results and Review→ Medication Profile→Impression and Plan (seen in bold in Table 10), or the likely path could continue Medication Profile→ Impression and Plan (seen in italicized and underlined in Table 10). Both paths then cycled between the Medication and Impression and Plan sections for the rest of the time steps.

**Table 10: First order Markov analysis for progress note 2**

| Time Step Number | Demo-graphics | Overnight Events | Review of Systems | Review and Manage-ment | Vital Signs | Physical Exam | Results and Review | Medi-cation Profile | Impres-sion and Plan |
|---|---|---|---|---|---|---|---|---|---|
| Start | **0.60** | 0.30 | 0.10 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 |
| 1 | 0.16 | **0.45** | 0.31 | 0.04 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 |
| 2 | 0.26 | 0.22 | **0.27** | 0.12 | 0.07 | 0.01 | 0.01 | 0.02 | 0.01 |
| 3 | 0.16 | **0.28** | 0.20 | 0.11 | 0.14 | 0.05 | 0.03 | 0.02 | 0.02 |
| 4 | 0.17 | 0.18 | **0.22** | 0.10 | 0.12 | 0.10 | 0.05 | 0.03 | 0.02 |
| 5 | 0.13 | **0.20** | 0.18 | 0.10 | 0.12 | 0.10 | 0.09 | 0.05 | 0.05 |
| 6 | 0.13 | 0.15 | **0.17** | 0.08 | 0.12 | 0.11 | 0.09 | 0.09 | 0.06 |
| 7 | 0.10 | **0.15** | 0.15 | 0.08 | 0.11 | 0.11 | 0.11 | 0.10 | 0.09 |
| 8 | 0.10 | 0.12 | **0.14** | 0.07 | 0.10 | 0.11 | 0.11 | ***0.14*** | 0.11 |
| 9 | 0.09 | 0.12 | 0.13 | 0.07 | 0.10 | 0.11 | 0.11 | **0.15** | ***0.14*** |
| 10 | 0.08 | 0.10 | 0.12 | 0.06 | 0.09 | 0.10 | 0.11 | ***0.18*** | **0.15** |
| 11 | 0.07 | 0.10 | 0.11 | 0.06 | 0.09 | 0.10 | 0.11 | **0.19** | ***0.17*** |
| 12 | 0.07 | 0.09 | 0.11 | 0.06 | 0.08 | 0.10 | 0.12 | ***0.21*** | **0.17** |

Table 11 shows the likely pathway through Note 3. Table 11 shows that participants again most likely started at the Demographics section (0.80), then transitioned between sections as follows: → Overnight Events→Review of Systems→Overnight Events→Vital Signs→Overnight Events→Results and Review→Impression and Plan→Results and Review and then cycled between Results and Review and Impression and Plan for the rest of the time steps.

**Table 11: First order Markov analysis for progress note 3**

| Time Step Number | Demo-graphics | Over-night Events | Review of Systems | Review and Manage-ment | Vital Signs | Physical Exam | Results and Review | Medi-cation Profile | Impre s-sion and Plan |
|---|---|---|---|---|---|---|---|---|---|
| Start | **0.80** | 0.10 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.05 | **0.63** | 0.24 | 0.03 | 0.04 | 0.00 | 0.01 | 0.00 | 0.00 |
| 2 | 0.24 | 0.11 | **0.29** | 0.11 | 0.16 | 0.03 | 0.05 | 0.00 | 0.01 |
| 3 | 0.09 | **0.28** | 0.13 | 0.13 | 0.18 | 0.10 | 0.04 | 0.01 | 0.05 |
| 4 | 0.12 | 0.11 | 0.17 | 0.09 | **0.18** | 0.11 | 0.14 | 0.02 | 0.05 |
| 5 | 0.07 | **0.15** | 0.10 | 0.10 | 0.16 | 0.12 | 0.14 | 0.05 | 0.11 |
| 6 | 0.08 | 0.09 | 0.10 | 0.08 | 0.16 | 0.11 | **0.19** | 0.06 | 0.13 |
| 7 | 0.06 | 0.10 | 0.08 | 0.07 | 0.15 | 0.11 | 0.20 | 0.07 | **0.16** |
| 8 | 0.06 | 0.08 | 0.07 | 0.06 | 0.14 | 0.11 | **0.22** | 0.08 | 0.17 |
| 9 | 0.05 | 0.08 | 0.06 | 0.06 | 0.13 | 0.11 | 0.22 | 0.09 | **0.19** |
| 10 | 0.05 | 0.07 | 0.06 | 0.05 | 0.13 | 0.11 | **0.24** | 0.10 | 0.20 |
| 11 | 0.05 | 0.06 | 0.05 | 0.05 | 0.13 | 0.11 | 0.24 | 0.10 | **0.21** |
| 12 | 0.05 | 0.06 | 0.05 | 0.05 | 0.13 | 0.11 | **0.24** | 0.10 | 0.21 |

### 4.3 Verbal Analysis

As mentioned, in a parallel study we examined participants' verbal handoffs. Table 12 depicts the verbal word count of each handoff. The verbal handoffs contained an average of 108 words for each note. Between notes there was little variation in word counts (range 100 – 113 words per handoff), however considerable variation between participants was found. Some participants summarized the progress notes in few words (averaging as few as 53 words per handoff) while other physiscians used more words to summarize the progress notes (averaging 196 words per handoff) [33].

**Table 12: Word count of each verbal handoff, by note**

| Participant | Note 1 | Note 2 | Note 3 | Avg | Std Dev |
|---|---|---|---|---|---|
| 1 | 158 | 237 | 194 | 196 | 39.6 |
| 2 | 157 | 176 | 181 | 171 | 12.7 |
| 3 | 66 | 72 | 67 | 68 | 3.2 |
| 4 | 98 | 73 | 94 | 88 | 13.4 |
| 5 | 56 | 66 | 113 | 78 | 30.4 |
| 6 | 53 | 60 | 51 | 55 | 4.7 |
| 7 | 43 | 59 | 56 | 53 | 8.5 |
| 8 | 133 | 104 | 86 | 108 | 23.7 |
| 9 | 78 | 94 | 87 | 86 | 8 |
| 10 | 161 | 190 | 189 | 180 | 16.5 |
| Average | 100 | 113 | 112 | 108 | |
| Std Dev | 47.7 | 64.1 | 55.7 | | |

Shown in Table 13, during the verbal handoff analysis we found the information within some categories could only be found in one section of a note while information in other stated categories could be found in more than one section. The Impression and Plan section appeared frequently as a source of information in the verbal handoff, either alone or in combination with some other section. We therefore coded information from the verbal handoffs into 3 groups: (1) Impression and Plan only, (2) Impression and Plan and other sections; and (3) Sections excluding the Impression and Plan. To quantify the distribution of the content in these three goupings, we calculated the number of times that one of these three groups was included in a verbal handoff divided by the number of categories in that verbal handoff. For example, for Note 1 subjects mentioned information related to 25 categories; 10 of these categories (40%) were found only in the Impression and Plan section, 11 (44%) could be found in the Impression and Plan and some other section. Only 4 of 25 catagories (16%) were exclusively found in sections other than the Impression and Plan. Across all notes, a majority of handoff information (84%) could be found in the Impression and Plan section (either exclusively or in combination) with only 19% of the handoff content found exclusively outside of the Impression and Plan section [30].

**Table 13. Potential sources of handoff information across notes**

| Potential sources of information | Note 1 | Note 2 | Note 3 | All |
|---|---|---|---|---|
| Impression and Plan only | 10 (40%) | 12 (44%) | 13 (52%) | 45% |
| Impression and Plan AND other sections | 11 (44%) | 10 (37%) | 6 (24%) | 35% |
| Sections excluding the Impression and Plan | 4 (16%) | 5 (19%) | 6 (24%) | 20% |

# CHAPTER 5

# DISCUSSION

The analysis of the visual and verbal data resulted in one overall theme. Participants focused most on the Impression and Plan section even though the amount of information in the sections of the progress notes varied immensely. For example, in Note 2, only 13% of the total character count could be found in the Impression and Plan section, but 60% of the total time spent reading that progress note was spent in that section; this can be seen in Tables 3 and 4, and Figures 5 and 9. In Figure 11, the timeline visualization of what the participants looked at while reading the progress notes, it is clear that all 10 participants heavily relied on the Impression and Plan section (the dark grey areas in the timeline) to glean the necessary information about the patients. In addition, the majority of information (84%) discussed in the verbal handoff was found either exclusively from the Impression and Plan section or a combination of the Impression and Plan section and another section. The participants' preferences for the narrative Impression and Plan section are also consistent with prior studies that emphasize narrative sources of patient information [34].

Does this mean that if something important is not in the Impression and Plan section it could be missed by physicians? Since the participants primarily focused on the Impression and Plan section to the extent that over 60% of the participants' total time reading was spent in that section, it may be that an error or a critical piece of information could be missed by physicians if it is somewhere other than the Impression and Plan section. For future studies, it would be interesting to find out whether, if critical information is not in the Impression and Plan section, it is mentioned by the participant in the verbal handoff. While it was not part of this study, Note 3 did have information in the Vital Signs section stating that the patient had high blood pressure but this information was not mentioned in the Impression and Plan section. Only two out of the ten physicians noted that the patient had high blood pressure in the verbal handoff. This needs to be addressed in future studies. This can be done by finding progress notes with critical information in sections that are not mentioned in the Impression and Plan section, then testing if physicians find this critical information. An error could also result from missing a combination of two things in different sections of the progress note. A high blood pressure in one section and then the patient being on a medication that raises blood pressure could lead to an error and future studies should address this. From Figures 11 through 13 and Tables 5 through 7 we can see the transitions of the 10 participants from one section to another. It can be seen that, to reach the Impression and Plan section, participants most likely transitioned from either the Medication Profile or the Results and Review sections; this finding is complimented by the sequential pattern analysis shown in Tables 9 through 11. This finding either means that the current layout of the Results and Review, Medication Profile and Impression and Plan sections being physically close together is a good layout or it means that the current layout is dictating the order the participants read the sections. Further studies should look at the impact of different layouts of the sections on the way physicians read through a progress note.

When participants were asked what their path was through the progress note they seemed to agree that they quickly go to the Impression and Plan Section (also called Assessment and Plan by the participants).

> *"When I look to give sign-out I tend to go straight to the summary section of the 'Assessment and Plan' because that tells you what's been going on with the patient since they've been in the hospital. I tend to gloss over the 'Physical Exam' and I'll gloss over a lot of the 'Labs' that get imported in. I don't spend a lot of time there."*

This impression of what the participants thought they did quite accurately described what we found in the first order Markov analysis. Participants tended to reach the Impression and Plan section relatively quickly.

In this study, the author of Note 3 decided not to include information in the Medication Profile section only including a reference to medications as "*medications reviewed*" in the Medication Profile section. Looking at Table 3 we see that the Medication Profile section in Notes 1 and 2 contained 32% and 55% of the total character count for each note respectively, whereas in Note 3 only 2% of the total character count was in the Medication Profile section. Looking at Table 3 and Figure 11 (the red areas) it can be seen that in Notes 1 and 2 the participants relied on the Medication Profile section quite heavily. In Note 3, however, the participants spent almost no time in the section as it only consisted of a heading. We can also see from the number of glances in each section, as depicted in Table 3 for Note 3, that even though the Medication Profile section only had a heading, participants still glanced at this section quite frequently. Although the Impression and Plan section was glanced at the most and for the longest amount of time in Note 3, both the Medication and Results and Review sections came in second in terms of number of glances in the respective sections.

This finding could mean several things. It could mean participants are used to having the Medication Profile section in their progress notes and that is why they kept glancing at that section or it could mean that during our experiment the participants read the other two progress notes first and they both had a Medication Profile section, so this is why they kept glancing at that section. It could also mean that the participants find that the Medication Profile section holds some value and leaving this information out might have been a mistake. In Notes 1 and 2 the participants spent about 10% of their total time in the Medication Profile section, the second highest time spent in the nine sections, so there must be some value in this section. In Note 3 they did not spend time reading that section because it did not contain information, but they did look at the section frequently. The first order Markov chain analysis showed that, in both Notes 1 and 2, the participants frequently switched between the Medication Profile and the Impression and Plan sections. This means that, participants heavily favored the Medication Profile section and the Impression and Plan sections when the Medication Profile section was in the progress note.

When the Medication Profile was not in the progress note, the Medication Profile did not show up in the typical path even though the number of glances in Medication Profile is quite high. This happens because the probability of transitioning from a section to the Medication Profile section is not high enough in Note 3 (see column MP in Table 7). This shows, however, that the participants may be conditioned to look for the Medication Profile section even though that section might not exist.

Looking at the transition probabilities with respect to the most likely transitions between sections (Table 5), and the first order Markov analysis (Tables 9 through 11), a hypothesis could be made about which sections should be placed physically next to each other. It could be the case that sections that have the highest transition probabilities should be physically next to each other; however further studies need to be done to form a more solid conclusion because the high transition probabilities could be the result of the current format of the progress notes. From this study it can be seen that it is very likely that if a participant is reading a certain section he will most likely transition to read the closest (physically) sections. Changing the order of the sections to see whether physicians read the progress note linearly could impact how future layouts of the progress notes should be ordered.

Participants were asked if the notes were believable and all agreed that the images we provided were reasonable representations of the way that progress notes appeared in the EHR. We also asked the participants to describe general strategies that they use when reading a progress note. In most cases, the participants said they generally approach the progress note by skimming some sections of the note and applying their attention selectively to the Impression and Plan section. The following is a quote of one of the participants [30]:

> *"I think I start at the top and go the bottom. I usually skim through things like 'Review of Systems'. I don't find that helpful. I don't really find the 'Vital Signs' helpful. I assume that if there is something really of issue it will be in the text of the note. 'Labs' I don't find helpful. I assume that will also be in the note if it's pertinent. So I usually spend the bulk of my time looking at….I think the text. In this case I did a little bit more comparison than I would normally do if I were writing my own note. I wanted to be sure that the physical exam matched what I was reading. But I would say I preferentially look to the bottom ('Assessment and Plan') of the note for my information."*

Participants were also asked to comment on other contexts in which they look at progress notes and whether the way they approach a note is influenced by context. Participants said that they mostly use the progress note if they are picking up a patient for the first time or being called about a patient as a covering provider overnight. In the first context, the progress note is typically used in addition to other sources of information (such as the admission note) while for cross-cover assessments the progress note is used to obtain a quick summary of the patient's clinical story. In both cases, the Impression and Plan is perceived as a valuable summary of patient information [30] .

> *"I look at the progress notes when I'm picking up patients. I look at them if I'm doing cross-cover and somebody's having an acute issue. If I'm picking up a panel of patients, I read all of their progress notes from the day before……In the interest of time, I usually drill down to the "Assessment and Plan". When I'm seeing my own patients I trust my own exam. I trust my own ability to look at the vital signs. So what I really want to know is, 'what am I walking into'."*

One participant noted that the synthesis of information in the Impression and Plan may not always be complete and for some participants the reliability of the source influenced how they approached a note [30]:

> *"Normally, I think I tend to jump to the plan from the start although it really depends on my source. If I don't trust the source…..I look at the author first. Who wrote it? If it's 'Oh, this guy's good', I'm going to look at his plan and I'm going to assume that whatever's in there is good. But if it's 'Oh, this guy's sort of a bonehead', I'm going to look at the whole thing. I'm going to look at the vitals, I'm going to look at the exam. I'm going to spend more time. I'm going to look at the pertinent labs and maybe even pull up the labs independently to make sure what's important is in there and then I'll look at his plan. So, a good practitioner, I just look at the plan, trust it and jump right to that."*

From what we saw in this study where the progress note was de-identified for privacy reasons, the participants did not know who the authors were and if they were trustworthy. All the participants relied heavily in the Impression and Plan section and did not read much in other sections. This could be for several reasons. Participants may have assumed that because this was an experiment of how they "usually" conduct a handoff that the author of the note was most likely is someone they can trust. One would think that if the source is unknown, the participant would err on the side of caution, but the participants seemed to read the progress note more in line to a known trusted author and in the verbal handoff focused mostly on the information that could be found in the Impression and Plan section.

Should the Impression and Plan section be located at the beginning of the note since the participants take most of the information from that section? Or will placing the Impression and Plan section at the beginning of the note lead to more errors because physicians might not bother to read any of the other sections? Based on this study, was it good to not include the Medication Profile section in Note 3? The participants had a great deal of glances at the Medication Profile section while reading Note 3. They may have wanted to compare something they read in another section to what should have been in the Medication Profile.

In addition, looking at better formats for the Impression and Plan section should also be considered, such as breaking the Impression and Plan section into more than one section, for example an Impression Section and Plan Section.

Many questions still need to be answered to improve the design of the progress notes; this is merely the first step.

Studying how participants visually navigated through progress notes using an eye tracker was effective because this device records where the participants directed their attention by recording where, when and how long the participants looked at areas of interest.

In the next part of the discussion, I will discuss the value of each analysis method

1. Glance Characteristics

a. Average time (AT): this was the most basic statistic we gathered using the eye tracker, seen in Table 3. This table is useful because it shows how long and how many times the participants looked at each section. The AT is the backbone of every analysis that we conducted.

b. Descriptive Graphs: Figures 5, 6 and 7 show how much more time was spent in the Impression and Plan section versus any other section when compared to the glance count (Figure 5) and the character count (Figure 7). Figure 8 shows that even though the character count varies quite a bit, glance number is always higher for the Impression and Plan section. Figure 10 depicts the ratio between the first glance duration and the average subsequent glance durations. Overall, this statistic is interesting because it describes whether or not the participants focused longer on each section the first time they read it, but no conclusions can be drawn from this data to improve the progress note design or the handoff process in terms of efficiency and effectiveness.

c. Timeline visualization: The timeline visualization is used to show a great deal of data. One of the things it does is it simplifies the explanation of the data in Table 3 so that all the important information in Table 3 can be viewed almost instantaneously. The timeline visualization actually gives more information than what can be seen in Table 3. For instance, it is quite easy to see that the Impression and Plan (dark grey) section was looked at the longest for all three progress notes. It can be seen that the red line (Medication Profile) shows up quite a bit for Notes 1 and 2 but is barely noticeable in Note 3. Where the timeline stands out is that each individual participant's path can be seen in the timeline as well as how long each participant spent in a section at a particular time. Overall, the timeline visualization is a valuable tool which provides a great deal of information intuitively.

2. Glance Patterns

    a. Transition probability analysis (TPA): this analysis is hard to understand without a backround in stochastic processes. To make this analysis more suitable for a person not familiar with stochastic processes, I created the visualization of the navigational pathways based on the TPA data. The results of the TPA can be seen in Tables 5 through 8. TPA can be one way to figure out what the order of sections should be in future studies. The highest transition probabilities for each section in the three progress notes" (page 31,) show sections that may be placed next to each other, when further studies on changes in the design of the progress note are done.

    b. Visualization of navigational pathways through the progress notes (Figures 11 through 13). These Figures strike a balance between information density and understandability and are a nice tool to visualize the TPA.

    c. Sequential pattern analysis (SPA): First order Markov chain analysis was used to analyze the path through each of the progress notes. After performing this analysis, we have an idea of the participants' navigation through the entire progress note. From this information we may be able to hypothesize how the order of the sections could be changed to increase the efficiency and effectiveness of the reading of the progress note, and the handoff process. This might be interesting for a further study using more subjects, and perhaps in more than one hospital which use the same progress note format as in the present study. The redesign could be done by analyzing recurring transitions in the SPA. Recurring transitions cannot be seen in the TPA. By looking at the frequency of the recurring transitions, relationships between sections can be established and could be the basis for changing the format of the progress note. For example, in Notes 1 and 2 of this study, the transitions kept repeating between the Medication Profile section and the Impression and Plan section. Looking at the less obvious transitions towards the beginning of the SPA, we can see that in Note 1 the transition Review of Systems →Vital Signs→Review of Systems occurred which suggests that these 2 sections should be placed together. The transition Overnight Events→Review of Systems occurred frequently in both Notes 2 and 3 which could mean that these 2 sections should be placed together as well. To make the SPA more useful, more progress notes need to be analyzed so that recurring transitions in the SPA can be found.

3. Verbal Analysis: the verbal analysis was a parallel study to the visual analysis. The information we gathered was useful because it allowed us to compare participants' visual scanning patterns with what they discussed during the handoff.

In addition to the future work already mentioned, other studies might be designed to:

- look at differences between experts and novices, for example residents and attending physicians to study if the two groups read the progress note differently;

- design and test a training program to teach physicians how to read progress notes and then checking whether there is a difference in finding errors in both groups;
- look at different interface configurations such as color coding critical information that might be out of the normal range, to see if adding this functionality would improve the effectiveness of the progress note;
- look if and how physicians and other healthcare professionals navigate to other information sources such as the actual lab results, electronic or not, during or after they read the note progress notes to see if they check if what is written in the progress notes match the other information sources.

This study has several limitations. Even though the results of this study are quite consistent, only 10 participants were used. In addition, this study was conducted in one hospital with one type of EHR. Further studies can look at other hospitals which use different EHRs to see if these findings can be replicated. This study only looked at an inpatient hospital progress note for an adult medicine service. Therefore it is not clear that the pattern observed in this study would be consistent across different medical services (e.g. Surgery, Obstetrics, Emergency Medicine, etc) or for other healthcare providers such as nurses, or respiratory therapists.

Furthermore this study only focused on the value of progress notes for the conveyance of clinical content to physicians. The progress notes used in this study are also used to support billing and providing evidence of care for medico-legal purposes. We did not assess how visual attention might vary depending on these contexts [33].

Some glances may be meant to help the physicians locate their place in the progress note as they scroll and might not mean they are gathering information, meaning that we cannot be absolutely certain that what they looked at was actually read and noted. The accuracy of the eye tracker we used did not allow us to be confident in what specific data elements within sections were glanced at, which means that we can only say that the participants looked at a particular section but what in that section was read could not be determined. We could not determine how the content the physicians' read in one section prompted them to look at another section. We also could not determine if the raw data (not the information in the Impression and Plan) lead the physicians to build a hypothesis and then use the Impression and Plan section to confirm it or, if the physicians read the Impression and Plan section to see what the hypothesis of the author of the progress note was, and then read the raw data to confirm the authors hypothesis.

# CHAPTER 6

# CONCLUSION

In this study, we used eye tracking technology to evaluate ten physicians' visual attention patterns as they read three progress notes. The goals of this research were to identify, evaluate, and use analytical methods to describe how physicians extract information from electronic progress notes during handoffs. The methods used to evaluate the handoff process, which included average time (AT) analysis, graphical representations, timeline visualization, transition probability analysis (TPA), visualization of navigational pathways through the progress notes, sequential pattern analysis (SPA), and verbal analysis all contributed to an overall understanding of how participants visually navigate through the progress notes.

From these analyses we determined that the participants glanced at the Impression and Plan section of the progress notes the longest. We determined that if the participant was currently reading in one section (s)he most likely would transition to the physically next closest section in the note, which means that the format of the progress notes may dictate how a progress note is read. We determined what the most likely path would be through the progress notes, which could be a first step in changing the ordering of the progress note for future studies, to determine if a different layout could improve efficiency and effectiveness of the handoff process. It may very well be that an error or a critical piece of information could be missed by physicians if it is somewhere other than the Impression and Plan section of the progress note.

In a parallel study we used verbal handoffs as a cognitive anchor to determine which information in the notes the participants thought were most important. We also asked debriefing questions to gauge participants' perceptions about how they read progress notes and what information in progress notes they perceived as most important. Despite variation in the content and volume of each of the three notes, the study participants overwhelmingly concentrated their visual attention on the narrative Impression and Plan section of the notes. The importance of this section was confirmed in that the majority of participants' verbal handoff content focused primarily on information that could be mapped to the Impression and Plan section of the progress note.

Participants' responses to debriefing questions suggest that they were aware of their reliance on the Impression and Plan section, but that the way they read notes is context-specific, depending on factors such as their use of the note and the author of the note. These findings suggest a need for more research that evaluates how different note structures and content affect how physicians and other providers extract and use information in varied clinical contexts.

# APPENDIX A

## PROGRESS NOTES 2 & 3

### Progress note 2

Medical Progress Note

Age: 69 years Sex: Female
Associated Diagnoses: None

Overnight Events & Current Issues
feels little better, 550 cc negative since last night

Review of Systems
Review of Systems
Respiratory: dyspnea improved.
Cardiovascular: orthopnea, peripheral edema.
Constitutional negative.
Gastrointestinal negative.

Review / Management
DVT Prophylaxis
Receiving subcutaneous heparin.
Foley Catheter

Physical Examination
Vital Signs
Vitals : VITAL SIGNS SECTION.
1/8/2010 11:37 Early Warning Score 6.00
1/8/2010 11:37 Temperature 97.5 DegF
Temperature Route Temporal
Pulse Rate 80 bpm
Respiratory Rate 18 br/min
Systolic Blood Pressure 133 mm Hg
Diastolic Blood Pressure 69 mm Hg
Blood pressure sites Arm, left
Mean Arterial Pressure 90 mm Hg
Oxygen Saturation 100 %
Liters per Minute 6 L/min
Mode of Delivery (Oxygen) Nasal cannula

Results Review
7 Day Results
Results
Laboratory : LABORATORY
1/8/2010 12:13 Glucose, POC 259 mg/dL H
1/8/2010 6:40 WBC 7.7 k/mm3
Hgb 11.4 Gm/dL L
Hct 33.8 % L
Platelet Count 140 k/mm3 L
RBC 3.80 m/mm3 L
MCV 88.9 femtoliters
MCH 30.0 pg
MCHC 33.7 %
RDW 13.4 %
MPV 11.9 femtoliters
Abs. Neut 6.8 k/mm3
Abs. Lymph 0.6 k/mm3 L
Abs. Mono 0.3 k/mm3 L
Abs. Eo 0.0 k/mm3
Abs. Baso 0.0 k/mm3
Neut % 88.5 % H
Lymph % 7.3 % L
Mono % 4.2 %
Eos % 0.0 %
Baso % 0.0 %
Sodium 135 mmol/L
Potassium 5.6 mmol/L H
Chloride 98 mmol/L
Bicarbonate Level 25 mmol/L
Anion Gap 12
BUN 66 mg/dL H
Creatinine-Blood 2.9 mg/dL H
Estimated GFR, Non African American 16 ML/MIN/1.73 M2
Estimated GFR, African American 19 ML/MIN/1.73 M2
Magnesium 1.7 mEq/L
Albumin 3.3 Gm/dL L
Alkaline Phosphatase 64 units/L
AST (SGOT) 15 units/L
ALT (SGPT) 17 units/L
Bilirubin, Total 0.3 mg/dL
CK, Total 107 units/L
CK MB Confirmation - Quant 5.4 ng/mL
Troponin T Quant 0.06 ng/mL

**Medication Profile**

**MED PROFILE**

**Medication Orders**

- **Insulin Glargine (Insulin Glargine Inj), 50 units, Injection, Subcutaneous Injection, Daily before dinner, Routine, 01/08/10 16:00:00**
- **Aspirin (Aspirin Tablet), 81 mg, EC Tablet, By Mouth, Daily, Routine, 01/08/10 8:00:00**
- **Famotidine (Famotidine Tablet), 20 mg, Tablet, By Mouth, Daily, Routine, 01/08/10 8:00:00**
- **Citalopram (Celexa Tablet), 40 mg, Tablet, By Mouth, Daily, Routine, 01/08/10 8:00:00, Refer to reference text / patient insert for additional medication information**
- **Aripiprazole (Abilify Tablet), 10 mg, Tablet, By Mouth, Daily at bedtime, Routine, 01/07/10 22:00:00, Refer to reference text / patient insert for additional medication information**
- **Simvastatin (Simvastatin Tablet), 20 mg, Tablet, By Mouth, Daily at bedtime, Routine, 01/07/10 22:00:00**
- **Sodium Chloride (NaCL 0.9% Flush), 3 mL, Injection, IV Push, Every 8 hours, Routine, 01/07/10 21:00:00**
- **Heparin (Heparin Inj), 5,000 units, Injection, Subcutaneous Injection, Every 8 hours, Routine, 01/07/10 21:00:00**
- **Nitroglycerin (Nitroglycerin 2% Topical), 1 inches, Ointment, Topically, Every 6 hours, Routine, 01/07/10 21:00:00**
- **Insulin Regular Human (Insulin REGULAR Human Sliding Scale), 2-12 units, Injection, Subcutaneous Injection, 3 times a day before meals and bedtime, PRN for Blood Glucose, Routine, 01/07/10 20:46:00, 150 - 199 2 units Call if less than 100**
  **200 - 249 5 units**
  **250 - 299 8 units**
  **300 - 349 10 units**
  **350 - 399 12 units Call if greater than 400**
- **Dextrose 50% in Water (Dextrose 50% Inj Syringe), 12.5 Gm, Injection, IV Push Slowly, Every 20 minutes, PRN for Blood Glucose, 50 to 70 and patient is NOT AWAKE or NPO; Repeat Glucose POC in 20 minutes, Routine, 01/07/10 20:46:00**
- **Dextrose 50% in Water (Dextrose 50% Inj Syringe), 25 Gm, Injection, IV Push Slowly, Every 15 minutes, PRN for Blood Glucose, LESS than 50 and patient is NOT AWAKE or NPO - call MD if episode NOT resolved within 20 minutes, Routine, 01/07/10 20:46:00**
- **Oxycodone / Acetaminophen (Percocet-5 Tablet), 2 tablet, Tablet, By Mouth, Every 4 hours, PRN for Pain , Moderate, Routine, 01/07/10 20:41:00, Not to exceed 4000mg of Acetaminophen per 24 hours.**
- **Docusate (Docusate Sodium Capsule), 100 mg, Capsule, By Mouth, 2 times a day, Hold for: Loose stools, Routine, 01/07/10 20:39:00**
- **Carvedilol (Carvedilol Tablet), 25 mg, Tablet, By Mouth, 2 times a day, Routine, 01/07/10 20:29:00**
- **Acetaminophen (Tylenol Tablet), 650 mg, Tablet, By Mouth, Every 6 hours, PRN for Pain , Moderate, Routine, 01/07/10 20:23:00**
- **Furosemide (Lasix Inj), 80 mg, Injection, IV Push Slowly, 2 times a day, Routine, 01/07/10 20:22:00, Refer to reference text / patient insert for additional medication information**

**Impression and Plan**

COMPREHENSIVE PLAN

This is a 69-year-old female with a history of chronic systolic and diastolic heart failure, chronic kidney disease, hypertension, hyperlipidemia and diabetes, who presents with the acute exacerbation of congestive heart failure.

1. Acute exacerbation of chronic systolic and diastolic heart failure. Patient reports 8 pound weight gain.
- started on IV lasix 80 bid
- watch weight daily
- watch I&O
- watch renal fucntion, put diovan on hold for now
- nitropaste
- cardiology consult (Dr. ), consider natrecor
- continue coreg
- ECHO done today - EF 35%, mild pulmonary hypertension
- cardiac rehab

2. Hypertension. Continue blood pressure medications.

3. Diabetes. Continue Lantus 50 units subcu each day at bedtime with insulin sliding scale.

4. Chronic kidney disease.
- watch closely
- hold Diovan
- avoid nephrotoxins

5. Hyperlipidemia. Continue statin.

6. Continue Abilify, trazodone and Celexa for history of depression. Pain control with morphine p.r.n. for chronic low back pain and osteoarthritis.

7. Deep venous thrombosis prophylaxis with heparin subcutaneously. Cardiac diet. The patient is full code.

# Progress note 3

**Medical Progress Note**

**Age: 75 years  Sex: Male**
**Associated Diagnoses: None**

**Overnight Events & Current Issues**
had an episode of chest discomfort last night, breathing is better, had 2 BM last night

**Review of Systems**
**Review of Systems**
**Respiratory: dyspnea improved.**
**Cardiovascular: chest pain.**
**Constitutional negative.**
**Gastrointestinal negative.**

**Review / Management**
**DVT Prophylaxis**
**on coumadin.**
**Foley Catheter**
**No.**

**Physical Examination**
**Vital Signs**
**Vitals : VITAL SIGNS SECTION.**

| | | |
|---|---|---|
| **1/15/2010 6:03** | **Systolic Blood Pressure** | **149 mm Hg H** |
| | **Diastolic Blood Pressure** | **87 mm Hg H** |
| | Blood pressure sites | Arm, right |
| | Mean Arterial Pressure | 108 mm Hg |
| 1/15/2010 5:04 | Temperature | 98.0 DegF |
| | Temperature Route | Temporal |
| | Pulse Rate | 80 bpm |
| | Respiratory Rate | 18 br/min |
| | **Systolic Blood Pressure** | **173 mm Hg H** |
| | **Diastolic Blood Pressure** | **100 mm Hg H** |
| | Blood pressure sites | Arm, right |
| | Mean Arterial Pressure | 124 mm Hg |
| | Oxygen Saturation | 96 % |
| | Mode of Delivery (Oxygen) | Room air |

**General Appearance**
**NAD.**
**HEENT**
**Moist mucous membranes.**
**Respiratory**
**Lungs: CTA.**
**Cardiac**
**Rhythms: RRR.**
**Abdomen/GI**
**Abdomen: soft, non-tender, non-distended, bowel sounds, no hepatosplenomegaly.**
**Extremities**
**Edema: grade 2 .**
**Neurologic**
**Alert & oriented x 3 .**

**Results Review**
**7 Day Results**
**Results**
**Laboratory : LABORATORY**

| | | |
|---|---|---|
| **1/15/2010 6:17** | **WBC** | **9.1 k/mm3** |
| | **Hgb** | **15.5 Gm/dL** |
| | **Hct** | **46.0 %** |
| | **Platelet Count** | **232 k/mm3** |
| | **RBC** | **5.18 m/mm3** |
| | **MCV** | **88.8 femtoliters** |
| | **MCH** | **29.9 pg** |
| | **MCHC** | **33.7 %** |
| | **RDW** | **14.5 %** |
| | **MPV** | **11.8 femtoliters** |
| | **Nucleated RBC (Automated)** | **0.0 #/100 WBC'S** |
| | **INR** | **2.0 H** |
| | **Protime (PT)** | **19.8 seconds H** |
| | Sodium | 141 mmol/L |
| | Potassium | 4.6 mmol/L |
| | Chloride | 102 mmol/L |
| | Bicarbonate Level | 29 mmol/L |
| | Anion Gap | 10 |
| | BUN | 15 mg/dL |
| | Creatinine-Blood | 1.2 mg/dL |
| | Estimated GFR, Non African American | 59 ML/MIN/1.73 M2 |
| | Estimated GFR, African American | >60 ML/MIN/1.73 M2 |

**Medication Profile**
**MED PROFILE**
**MED PROFILE reviewed.**

**Impression and Plan**

**COMPREHENSIVE PLAN**

The patient is a 75-year-old gentleman with history of coronary artery disease status post coronary artery bypass grafting, history of congestive heart failure with ejection fraction of 10%-15%, came with an onset of chest pain accompanied by shortness of breath. He was also recently started on Kayexalate and he has been constipated since then. On admission, initial workup consistent with mild congestive heart failure exacerbation.

1. Congestive heart failure exacerbation.
- doing better
- continue po lasix
- watch UOP (500 cc negative since yesterday)
- cardiology consult appreciated
- will repeat CXR

2. Chest pain. The patient has a history of CAD.
- cardiac enzymes are negative

3. Constipation, could be related to Kayexalate.
- had 2 BMs after the lactulose

4. Hyperkalemia.
- resolved

5. Diabetes. Continue insulin Lantus 24 units at bedtime, check blood sugars before each meal and at bedtime. Cover with insulin sliding scale.

6. Dispo: home within next 24-48 hours if remains stable

# APPENDIX B

## FIRST ORDER MARKOV ANALYSIS

First order Markov analysis is done by the operation a*P^n where the vector “a” is the initial starting point of the participants. The vector “a” can be seen in table 9 through 11 under the time step column as “start.” Fifty percent of the participants started out by reading the Demographics section , and 30% of the participants started reading the Review of Systems section in Note 1. “P” is the Transition matrix (see Tables 5 through 7 for the P matrix), and “n” is the time step (a specific point in time). If we wanted to calculate what the probability is of being in each state at time step 3, we would calculate a*P^3. The results of this calculation can be seen in Tables 9 through 11 and can be read by reading across the time step row labeled 3.

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