BIOMEDICAL INFORMATICS

IMPROVING PROVIDER-TO-PROVIDER COMMUNICATION: EVALUATION OF A COMPUTERIZED INPATIENT SIGN-OUT TOOL

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Thesis under the direction of Professor Lemuel R.Waitman

Physicians' use of a computerized inpatient sign-out tool has been shown to reduce the risk of preventable adverse events. The researcher evaluated sign-out software usage at Vanderbilt University Medical Center in order to understand user behavior and identify software enhancements. To accomplish these goals, the researcher created software to record sign-out data, determined descriptive statistics of software utilization, collected feedback from users regarding new software enhancements, and analyzed the content produced by sign-out tool users. Results included the identification of unanticipated software usage by non-providers, different use patterns across hospital units/services, and a variety of discipline-specific sign-out note styles. These results combined with a comparison to the literature's recommendations guided the design specification for new sign-out software. Further study is required to determine relevant outcome measures related to both the sign-out process and the impact of sign-out software.

Approved ____ Date ___________

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My parents, sister, and friends provided love and emotional support over the course of this project. Without them the research process would have been considerably more difficult.

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LIST OF ABBREVIATIONS

ACGME .... Accreditation Council for Graduate Medical Education

APS ....acute pain service

BMP ....basic metabolic profile

CCL ....cardiac catheterization lab

CPOE..care provider order entry

CXR .... chest x-ray

DBMI .... Department of Biomedical Informatics

EMR ....electronic medical record

ENT .... ear nose throat

JCAHO .... Joint Commission on Accreditation of Healthcare Organizations

LOS .... length of stay

NICU ....neonatal intensive care unit

NIDDM ....non-insulin dependent diabetes mellitus

PCCU ....pediatric critical care unit

PDA.. personal digital assistant

PEA ....pulseless electrical activity

PHV...Psychiatric Hospital at Vanderbilt

POD..post operative day

VCH .... Vanderbilt Children's Hospital

VUH .... Vanderbilt University Hospital

VUMC..Vanderbilt University Medical Center

CHAPTER I

INTRODUCTION

A 73-year-old female with history of hypertension, non-insulin dependent diabetes mellitus (NIDDM), and chronic renal insufficiency was admitted for an elective sigmoid resection and diverting colostomy. On postoperative day (POD) 2, the patient was tachycardic, despite receiving a low-dose beta-blocker. That same day, she informed her nurse that she had developed left leg pain. Assuming it was related to the epidural placed preoperatively, the nurse called anesthesia, and they responded by decreasing the epidural rate. The primary surgical team was not called at that time. On POD 3, the patient had no complaints for the primary team on morning rounds. Later in the evening, the cross-covering intern was called concerning the left leg pain. No information about this intern's findings was relayed to the primary team the next morning. On POD 4, the patient complained to the nurse of mild chest discomfort. She was seen by housestaff within 20 minutes and by the attending several hours later. Her exam was unremarkable. A workup was initiated, but within an hour of the attending's visit, the patient's blood pressure dropped to 70/40, followed shortly thereafter by a pulseless electrical activity (PEA) arrest, from which she could not be resuscitated. Post-mortem examination revealed pulmonary embolism [1].

The Institute of Medicine estimates 44,000 to 98,000 people die in United States hospitals annually because of preventable medical errors, “the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim” [2]. No stage of the patient care process is immune from error. The effects of preventable medical errors affect society financially (entities spend $30 billion annually), emotionally (patients lose trust in the health care system), and professionally (health care workers become dissatisfied with their jobs) [2]. Although humans have the capacity to make errors, we also have the ability to learn about and prevent errors. By studying past medical errors, researchers can discover ways to improve patient care processes to prevent the occurrence of new errors [2].

Communication is central to healthcare. Multidisciplinary teams of healthcare professionals exchange patient information to coordinate care processes. The combination of face-to-face, telephone, and electronic communication forms makes for an increasingly complex clinical environment that is vulnerable to failure [3]. According to the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), communication failures are the most common cause of sentinel events, or "unexpected [occurrences] involving death or serious physical or psychological injury, or the risk thereof" [4]. The relationship between patient care errors and communication failures is notable. Because communication is so critical to high quality patient care, further study is warranted.

Communication in twenty first century healthcare exists in many forms: patient-to-patient, patient-to-organization, patient-to-provider, provider-to-provider, provider-to-organization, and organization-to-organization [5]. This research targeted one component of provider-to-provider communication, namely inpatient handoffs. To effectively study all provider-to-provider communication would require a complex and longitudinal research methodology.

Healthcare providers with the authority to execute orders (e.g. attending physicians, resident physicians, and nurse practitioners) usually communicate with each other to execute requested consultations, "curbside consults" [6], and patient handoffs, called "sign-out," using verbal and written communication strategies, whether direct or through information technology. Previous studies regarding the transfer of patient care information and responsibilities between resident physicians in teaching hospitals indicate the process is prone to communication failure [7-9]. In 2003 the Accreditation

Council for Graduate Medical Education (ACGME) imposed an 80-hour weekly work limit on resident physicians with the intent of improving patient safety by reducing house staff sleeplessness. One effect of the ACGME's ruling increased the number of transfers of patient care between providers [10]. Each transfer of a patient's care is an opportunity for communication failure and the occurrence of a sentinel event [4]. Investigating transfer of care procedures can yield insights into how to prevent the communication failures that contribute to preventable medical errors and mortality.

In this master's thesis, the researcher analyzed sign-out procedures at a large teaching hospital to identify ways to improve the transfer of information between providers. Previous published research of sign-out software usage and the content produced using sign-out software has not been performed. The researcher designed and implemented software to collect data about the institution's computerized sign-out procedures and analyzed it to determine how sign-out information was being used. Sign-out procedures and information were evaluated against published recommendations and other institution's methods. From the analysis, the researcher identified ways to improve Vanderbilt University Medical Center's method of managing sign-out information. A better understanding of the communication task of provider sign-out can potentially lead to improvements that reduce the number of communication failures and preventable medical errors.

CHAPTER II

LITERATURE REVIEW

The researcher reviewed literature pertaining to the provider-to-provider communication task of sign-out. Concepts relevant to this area of study include clinical communication, continuity of care, patient handoff and sign-out, sign-out standardization, and computerized sign-out applications.

Communication

With patients, health professionals, health centers, payers, information resources, and government organizations exchanging information to coordinate and compensate services, communication is an indispensable part of healthcare delivery. As Toussaint and Coiera state, "[if] information is the lifeblood of healthcare, then communication is the heart that pumps it" [11]. Healthcare system participants communicate with each other using a combination of face-to-face, telephone, and electronic communication forms [3]. The communication needs of administrative organizations (e.g. payers and government agencies) differ from the needs of clinical settings in that clinical settings focus on "information flow to and from the healthcare provider" [12]. Furthermore, the communication needs of outpatient and inpatient settings differ because of patients' length of stay and acuity. The transfer of information between inpatient and outpatient settings is also crucial to high quality patient care. For healthcare professionals, the requirements for communication differ based on whether individuals exchanging information work in the same organization [3] and same patient care team [12].

Despite the growth of innovative ways for patients, providers, and organizations to exchange information, communication in patient care settings remains largely interruptive [13]. Coiera suggests healthcare communication occurs via synchronous and asynchronous channels; synchronous channels are interruptive by the nature of simultaneous information exchange, whereas asynchronous channels enable exchanges to occur at different times [3]. In a study of communication behaviors in an Australian hospital, individuals involved in patient care seemed to prefer synchronous communication methods (e.g. face-to-face, telephone, and pager interactions) to asynchronous ones [13]. Not only do interruptions contribute to care process inefficiencies, they also can contribute to providers' cognitive burden that leads to patient care errors [14]. Communication failures are the most common cause of sentinel events in the United States [4]. From the perspective of cognitive psychology, replacing synchronous communication with asynchronous communication where appropriate can reduce the chance of providers experiencing memory lapses that contribute to medical error [14]. Although researchers call for the substitution of synchronous communication forms with asynchronous ones, such claims would need to be tested and proven before attempts to change the existing culture of medical staff could be made.

Continuity of care

The term "continuity of care" refers to "how individual patients experience integration of services and coordination" from members of the healthcare team over time

[15]. Examples of continuity of care range from the ephemeral to the long-term: emergency department visits lasting hours, inpatient hospitalizations lasting days, and relationships between patients and primary care physicians lasting years [15]. In teaching hospitals, the team responsible for the continuum of care includes attending physicians, resident physicians, medical students, nurse practitioners, nurses, and ancillaries. The central tenet of continuity of care is communication between providers regarding the needs of a patient [16]. Providers, patients, and healthcare organizations share the common goal of improved care, but "discontinuity…threatens professional identity, patients' expectations, and information management if it is not adequately addressed" [17].

Discontinuity of care is at times inevitable [17], as is the case during cross-coverage, the care provided by resident physicians who are not part of a patient's regular care team. In a study of housestaff coverage at an urban academic medical center, Petersen et al found a correlation between discontinuity of care provided by housestaff and the occurrence of potentially preventable adverse events. Specifically, "patients' risks for potentially preventable adverse events were increased when the patients were cross-covered by physicians from another team" [18]. The authors identified communication of patient information between providers as a factor that can cause difficulties in cross-coverage [18]. Despite Petersen's focus on patient outcomes, most continuity of care studies focus on resident outcomes [17]. More continuity of care research is necessary, and Fletcher et al call for the development of continuity of care measures relevant to patient outcomes [17].

Handoff and sign-out

A review of the literature outlines terms that are helpful in understanding the transfer of patient care. One term is “handoff,” “the transfer of rights, duties, and obligations from one person or team to another” [19]. Arora states that a “handoff can be thought of as a communication of information…that can take place through different modalities, which can include a written or verbal component” [10]. Handoffs exist in many forms and involve different members of the patient care team to maintain continuity of care. JCAHO identifies several types of handoffs in patient care: “nursing shift change, physicians transferring complete responsibility for a patient, physicians transferring on-call responsibility, temporary responsibility for staff leaving the unit for a short time, anesthesiologist report to post-anesthesia recovery room nurse, nursing and physician hand off from the emergency department to inpatient units, different hospitals, nursing homes and home health care, [and] critical laboratory and radiology results sent to physician offices”[20]. The breadth of patient handoff goals—and the clinical activities and professional roles involved—provides numerous avenues for research. The handoff type JCAHO identifies as “physicians transferring on-call responsibility” is also called “sign-out.” The term “sign-out” encompasses the transfer of on-call responsibility and information in inpatient settings from a provider ending a shift to a provider beginning a shift [7, 21, 22]. Sign-out “familiarizes the [provider] on call (sic) with hospitalized patients and the potential problems that might arise overnight” [21]. In teaching hospitals sign-out generally involves resident physicians [22], as well as nurse practitioners. Sign-out in teaching hospitals is the focus of this study.

Clinical communications, including sign-out, involve a combination of organizational, social, physical, and informational factors. In a survey of resident work activities and medical mishaps at a large U.S. teaching hospital, Sutcliffe found that communication failures were related to 91% of reported medical mishaps. Sutcliffe's interviews with resident physicians "show that communication failures arise from vertical hierarchical differences, concerns with upward influence, role conflict and ambiguity, and struggles with interpersonal power and conflict" [23]. In another study, Arora identified communication failures at physician sign-out as contributing to residents' uncertainty in making decisions [7]. To improve sign-out, Solet suggests residents in the U.S. exhibit English language proficiency to clearly express clinical concepts, perform handoffs face-to-face in a quiet environment to minimize distractions, and exchange a written sign-out report to reinforce their verbal exchange [19]. Multiple aspects of communication affect sign-out procedures, and sign-out procedures can influence the quality of patient care.

Standardization

Standardized sign-out procedures can promote effective communication between providers so that providers can limit care process variability and subsequent undesirable outcomes [19]. In a study evaluating the effectiveness of sign-out procedures, residents using a standardized sheet of paper to perform sign-out reported experiencing a better sign-out than those who did not use a standardized sheet [21]. Despite apparent benefits of standardization, many sign-out procedures have high levels of variability. Solet describes the non-standardized patient sign-out process at Indiana University School of

Medicine that involves four hospitals and three electronic information systems of varying levels of sophistication [19].

In a survey of 202 residency programs in internal medicine at U.S. hospitals, Horwitz identified variability in sign-out processes "among and within institutions" [22]. Although most respondents indicated always performing a written or verbal sign-out, 45% of respondents performed both written and verbal sign-out. Of those residency programs in Horwitz's study that required written sign-out, 45% used computer word processing software, 29% wrote notes by hand, 14% used web applications or clinical information systems, 7% used a computer program that automatically imported patient information from a clinical data repository for sign-out, and 5% used a combination of approaches. Survey responses also indicated variability in sign-out training, participation of interns and residents, and notifications that handoffs had occurred.

Accounts of adverse patient care events caused by communication failure during patient handoff [1, 24-26] underscore the importance of eliminating care process variability through standardization. Handoff standardization is a 2007 National Patient Safety Goal of the Joint Commission for the Accreditation of Hospital Organizations (JCAHO) [27]. In U.S. hospitals, much remains to be done to standardize sign-out procedures.

Process standardization lessons from other industries have been introduced to medicine for the purpose of improving handoffs [28]. One example is in applying crew resource management techniques to create a "common and predictable structure" during clinical shift change communication [29]. Arora addresses patient handoff process variability by creating a model for standardized handoff communication [10]. Arora's model relies on two assumptions: customizing standardized handoff procedures for individual organizations and the disciplines within them; and standardizing the *process* and *content* of those handoffs. Process standardization involves identifying the order of cognitive and physical activities required to successfully complete a task and makes them mandatory. Content standardization involves identifying the checklist of necessary information to perform a handoff. It serves two purposes: ensuring that clinicians transfer the correct information, and instructing those unfamiliar with the handoff process of what needs to be done. Arora's method for creating standardized protocols is intended to generalize within and beyond targeted organizations, whereas the standardized protocols created by the method are intended to be used in individual settings.

Research on patient handoff suggests the need for standardizing patient handoff protocols through clinicians' use of computerized systems. Because "low technology formats" are the sign-out status quo, Horwitz posits that sign-out stands to gain from the application of cutting edge techniques [22]. Solet proposes a list of "essential elements for successful handoffs" for use in conjunction with computerized sign-out systems [19], and several researchers have published the data elements used in their institutions' sign-out applications [30-34].

Computerized sign-out

The use of computerized sign-out applications has been shown to improve clinical outcomes. As a follow-up to a study showing a correlation between cross-coverage and preventable adverse events in a teaching hospital [18], Petersen showed computerized sign-out "improves continuity of care during cross-coverage and thereby reduces risk for preventable adverse events" [31]. The sign-out application was well-received by physicians for communicating patient information for cross-coverage, and also became part of physicians' workflow for the management of their regular patients. Use of the sign-out tool "augments, but does not replace, face-to-face transmission of patient information" [31]. Petersen's study focused on the effect of computerized sign-out on preventable adverse events and minimally addressed the software's structure and development.

Most existing literature about computerized sign-out systems focuses on the development of tools in institutions where such systems did not previously exist. Van Eaton described the development of a sign-out tool in two of the teaching hospitals served by University of Washington residents. At the core of Van Eaton's approach was the similarity of information used at sign-out and in "ward work" (daily patient care tasks), and how that information can be managed by a single computer system to improve efficiency for resident physicians. The study included an evaluation of workflow, identification of pertinent data elements, identification of user preferences, integration of existing systems, design of new system functionality, and implementation of the tool in the institution [34]. In a separate study, Van Eaton showed improvements in provider workflow and continuity of care based on a randomized controlled trial using physician self-report data [35]. Researchers have performed similar studies chronicling the development of sign-out applications at other institutions, although without extensive followup evaluation studies like Van Eaton's [30, 32, 36]. Sidlow described the positive impact on care processes that occurred when nurses were allowed to use a sign-out application previously available only to physicians [33]. Lei et al examined sign-out note content to determine headings for structured data entry of sign-out notes and developed a parser to identify sections corresponding to headings in both structured and unstructured notes [37]. Use of personal digital assistants to manage sign-out information has been well-received by clinicians [37, 38], and scholars have identified mobile technology as a potential boon to continuity of care [39]. The use of computerized tools has been identified as helpful at sign-out.

Summary

The literature contains examples of sign-out tools developed *de novo*, but analysis of existing tool usage with respect to other information systems and care processes at informatics-rich institutions is lacking. The literature suggests numerous factors influence sign-out. Process involves the context of work organization—hierarchy, power, influence, time, setting, education, technology, and other factors—whereas content involves the data used to perform a handoff. An improved understanding of sign-out content can potentially lead to the development of sign-out procedures that produce fewer communication failures and subsequent medical errors.

CHAPTER III

RESEARCH OVERVIEW

In this section, the researcher presents the rationale for this study and describes the study environment, including demographics of the targeted institution, pervasive and embedded nature of informatics at the institution, history of the computerized sign-out tool, legal issues of sign-out tool usage, and the institution's changing informatics environment.

Study rationale

This research focused on one component of provider-to-provider communication—inpatient sign-out. The computerized sign-out tool has replaced the pen and paper as the method for recording information to transfer patient care responsibility at Vanderbilt University Medical Center. Computerization improves legibility of notes and provides opportunities for analysis of the content of notes. Although the literature describes the development and implementation of computerized sign-out tools, there are no published reports thoroughly analyzing the content generated by users of computerized sign-out tools. Evaluation of sign-out content can help researchers understand the information produced by providers involved in provider-to-provider communication. This knowledge can guide the development of new sign-out software aimed at reducing communication failures and the occurrence of sentinel events.

Additionally, understanding the content of sign-out can provide a better understanding of the process of sign-out and improvements that can be made to it.

This research evaluated the current use of the computerized sign-out tool at Vanderbilt University Medical Center against published recommendations and findings to provide insights for the design of sign-out software. This research focused on the content, not the process, of sign-out. In accordance with Arora's work on standardized patient handoff protocols [10], this research aimed to understand current sign-out tool uses in order to tailor sign-out to disciplines at Vanderbilt University Medical Center. The researcher sought answers to open problems regarding the content of sign-out notes: Can researchers use sign-out software to measure continuity of care outcomes? What do users write in the free text sections of sign-out notes? What trends, patterns, and discrepancies appear in sign-out notes? What data should sign-out software include? How should sign-out software capture and present data? The evaluation questions and research hypotheses presented in table 1 directed an investigation of the information (content) used in a computerized sign-out tool:

Table 1: Research questions and hypotheses

1. Who generates sign-out notes?	Providers generate sign-out notes.
2. Who prints sign-out notes?	Providers print sign-out notes.
3. Is sign-out tool utilization similar across hospital units/services?	Sign-out tool utilization is similar across units/services.
4. Is the content users generate with sign-out software similar across hospital units/services?	Sign-out note content is similar across units/services.

Testing these hypotheses provided the researcher with sufficient knowledge to assess the previously identified open-ended questions.

Research site

Vanderbilt University Hospital (VUH), Vanderbilt Children's Hospital (VCH), the Psychiatric Hospital at Vanderbilt (PHV), and Stallworth Rehabilitation Hospital provide inpatient services as part of Vanderbilt University Medical Center (VUMC) in Nashville, Tennessee. VUMC is a large, urban, tertiary care facility that is a major regional referral center and a Level 1 trauma center. Across all of its hospitals, VUMC is licensed for 832 beds and admits 42,611 patients annually. 627 resident physicians and 193 clinical fellows provide care across the VUMC hospitals [40]. An informatics-rich institution, VUMC is served by the Department of Biomedical Informatics (DBMI), an academic research unit in the Vanderbilt University School of Medicine, and the Informatics Center, an internal informatics consulting and management organization. Several DBMI personnel participate in Informatics Center operations as part of their research projects.

Informatics at Vanderbilt

To manage patient data and billing, Vanderbilt clinicians use a number of computerized systems developed internally and purchased from third party vendors, a so-called "best of breed" approach [41] to clinical information systems. The institution's electronic medical record (EMR), StarPanel [42], and inpatient care provider order entry system (CPOE), WizOrder [43-45], are the product of DBMI faculty research. StarPanel aggregates patient information from disparate sources and provides documentation capabilities through StarNotes and StarForms. StarNotes provides template-based free text data entry for a variety of notes, while StarForms provides template-based point-and-click data entry [46]. StarNotes and StarForms are used in nearly all inpatient and outpatient settings. Another structured data capture product developed internally, Quill, is used in a small number of clinical settings for documentation.

An industry partnership with McKesson Corporation that resulted in the commercialization of WizOrder as Horizon Expert Orders [45] helped usher in McKesson products to the institution: Horizon Expert Documentation for nursing documentation, Horizon Meds Manager for pharmacy, and Horizon AdminRx for medication administration. Aside from McKesson products, VUMC uses GE Medical Systems Triple G system to manage laboratory data, IDXRad and Agfa PACS and for radiological imaging, and scheduling and billing solutions from Epic Systems. An extensive in-house system, including an "electronic whiteboard," manages all patient data in the emergency department. Myriad other systems from vendors or and internal developers are also in use. New tools envisioned by DBMI researchers and Informatics Center management include "dashboards" displaying indicators of care performance, inpatient whiteboards aggregating unit or service information, and improved call scheduling.

Sign-out tool background

Sign-out tool use is an established practice in VUH and VCH. In 1997 Antoine Geissbühler, M.D., the initial developer of WizOrder [43], developed the sign-out tool in response to user requests. A demonstration of the sign-out tool at Brigham and Women's Hospital [31] also influenced Geissbühler to develop software to facilitate physician-to-physician handoff. Geissbühler continually modified the tool to match users' needs.

Embedded within WizOrder, the sign-out tool fit with physician workflow and developed a large number of users across the institution [47].

A decade later the sign-out tool's functionality, content, and structure remained largely unchanged. The tool is accessible by any user from any inpatient clinical workstation. Users access the sign-out tool via WizSTAT, the default workstation desktop portal and screensaver, as depicted Figure 1, through a series of two mouse clicks, as shown in Figure 2. Based on either a user-specified list of patients called a "scratch census" or a hospital unit/service's census, as shown in Figure 3, the user can view, modify, and print "sign-out notes," which consist of demographics, current information from orders, a "case summary" section, and a "to check" section for each patient. The sign-out tool parses demographics and current information from the hospital interface engine, and users contribute text to "case summary" and "to check" sections. Figure 4 shows the user's view of the sign-out tool. Figure 5 presents an overview of the sign-out tool's system architecture and data elements. When a current information element is not specified in a patient's active orders, the sign-out tool displays a "___" following the data element's label to indicate it is blank. The intent of the "case summary" is a narrative of a patient's current hospitalization, while the "to check" is a list of issues that demand immediate attention. Text from both of these fields is saved to a set of text files on a fileserver so that users can retrieve and update the information during the patient's stay. Each time a user saves a sign-out note, the existing set of files is overwritten with the newest changes. The sign-out tool does not save any other information. Users view all patients on a single page and execute the following actions on the list of all patients: save and print, save, clear all "to check" sections, close without saving, close and save. Users routinely print sign-out information and use the materials away from computer terminals. Whether on-screen or on a printout, the sign-out tool lists patient ordered by hospital bed number.

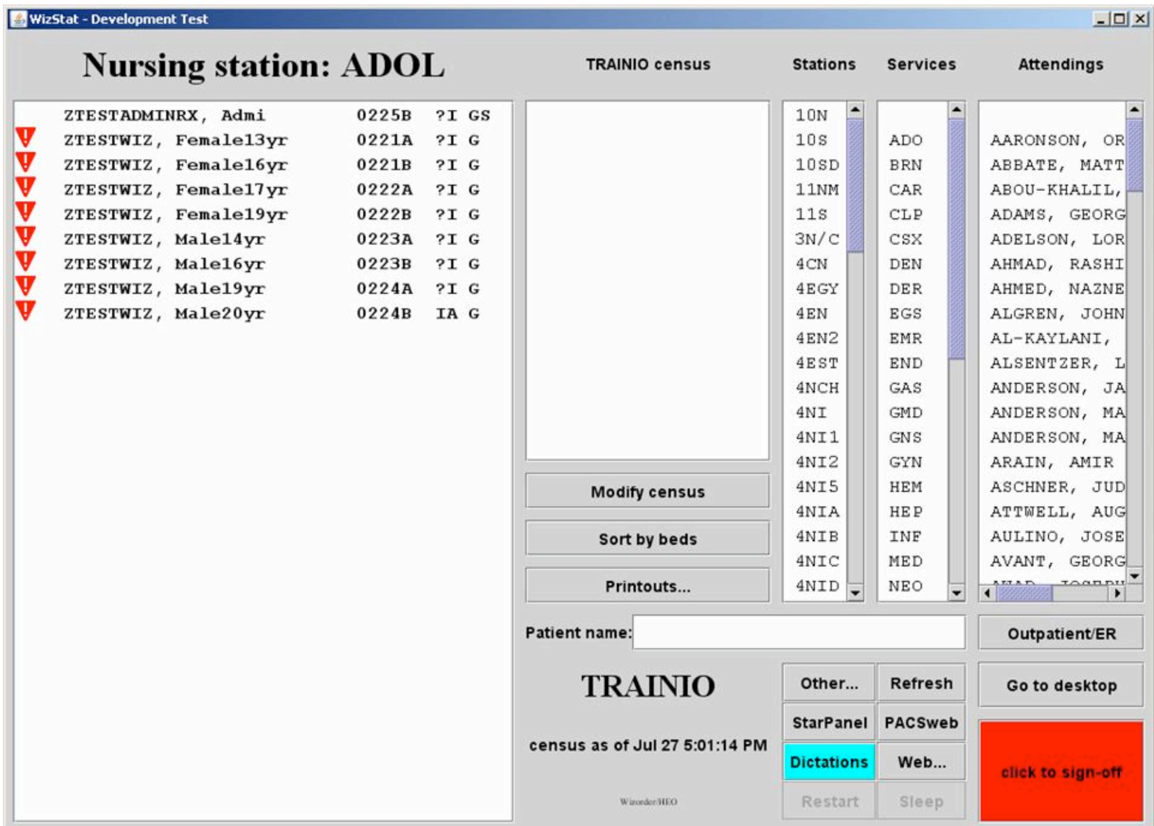

Figure 1. WizSTAT, the default workstation desktop portal and screensaver

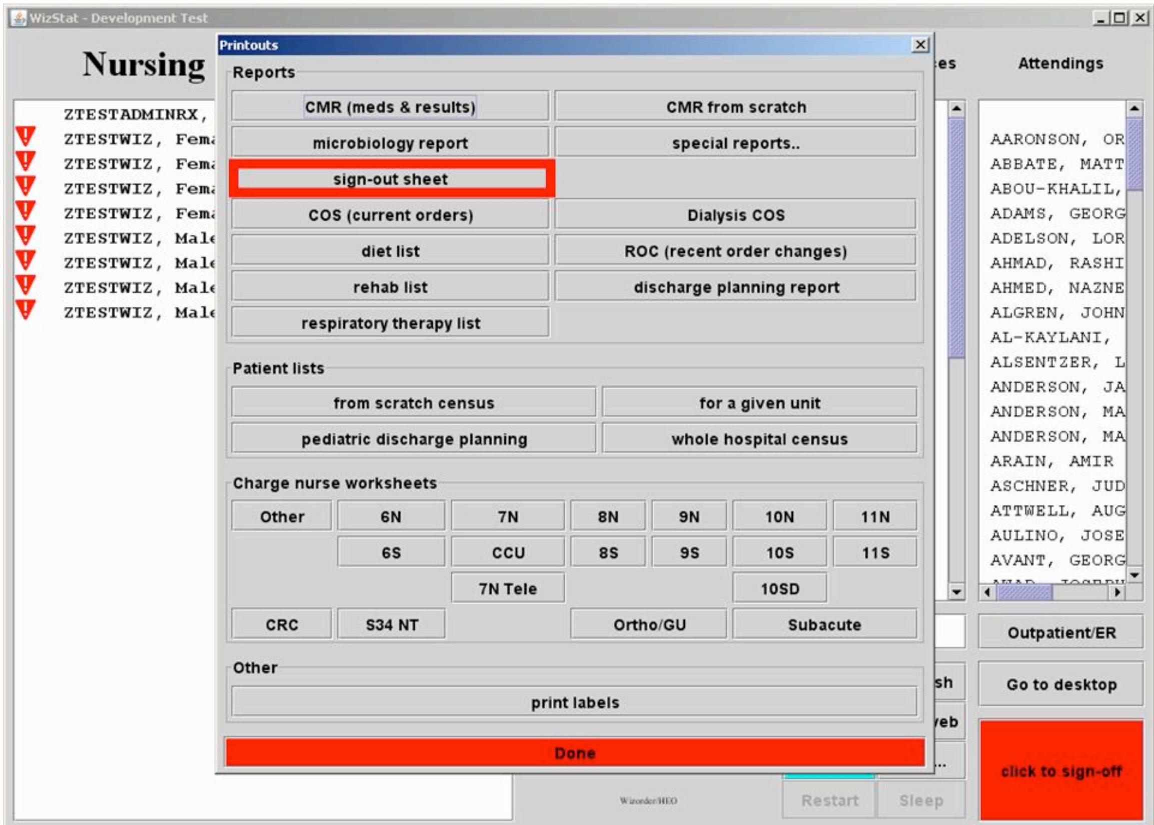

Figure 2. Printouts dialog box, the screen from which to access sign-out

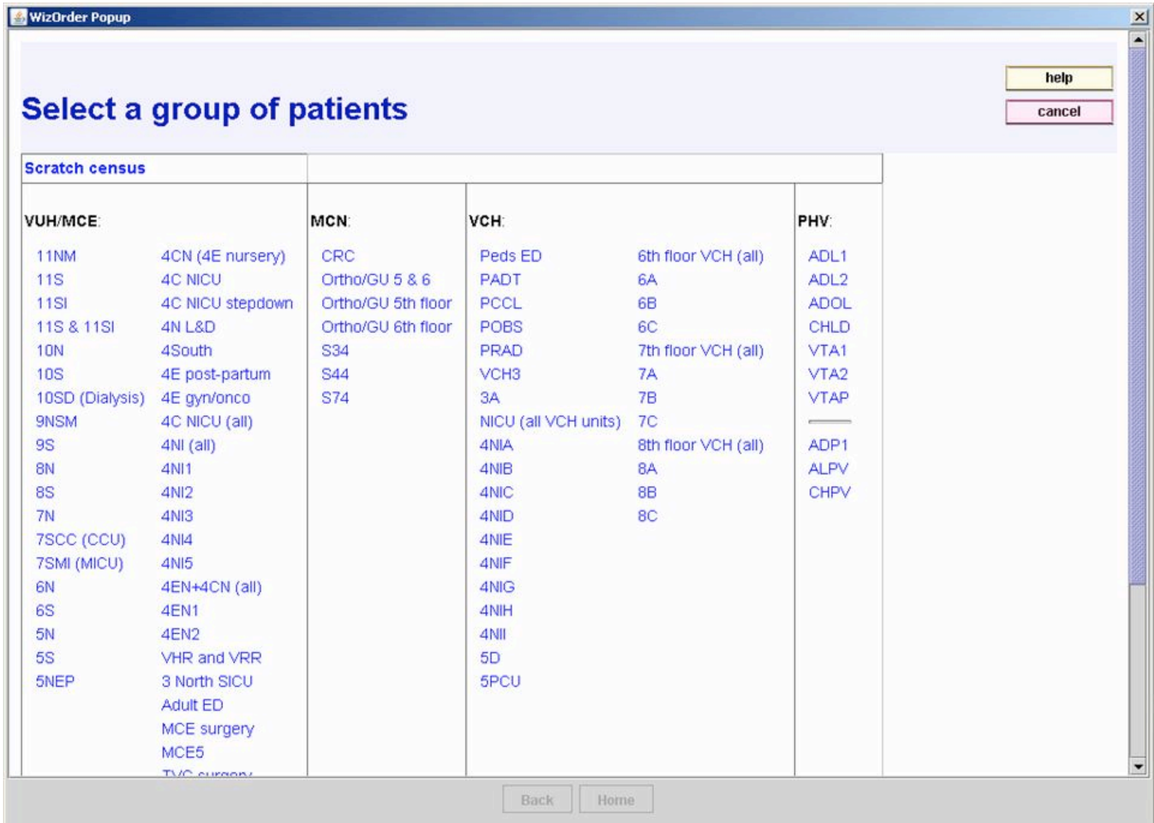

Figure 3. Selecting a group of patients to sign-out

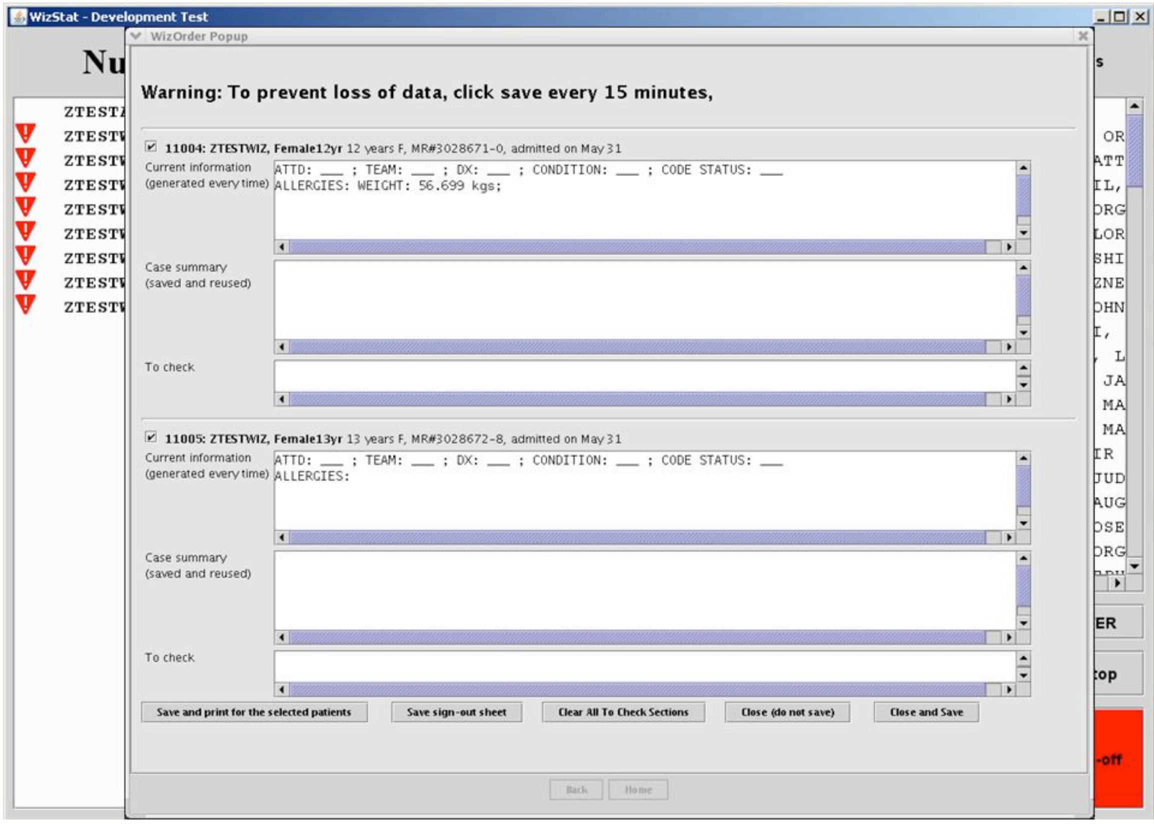

Figure 4. User's view of sign-out tool

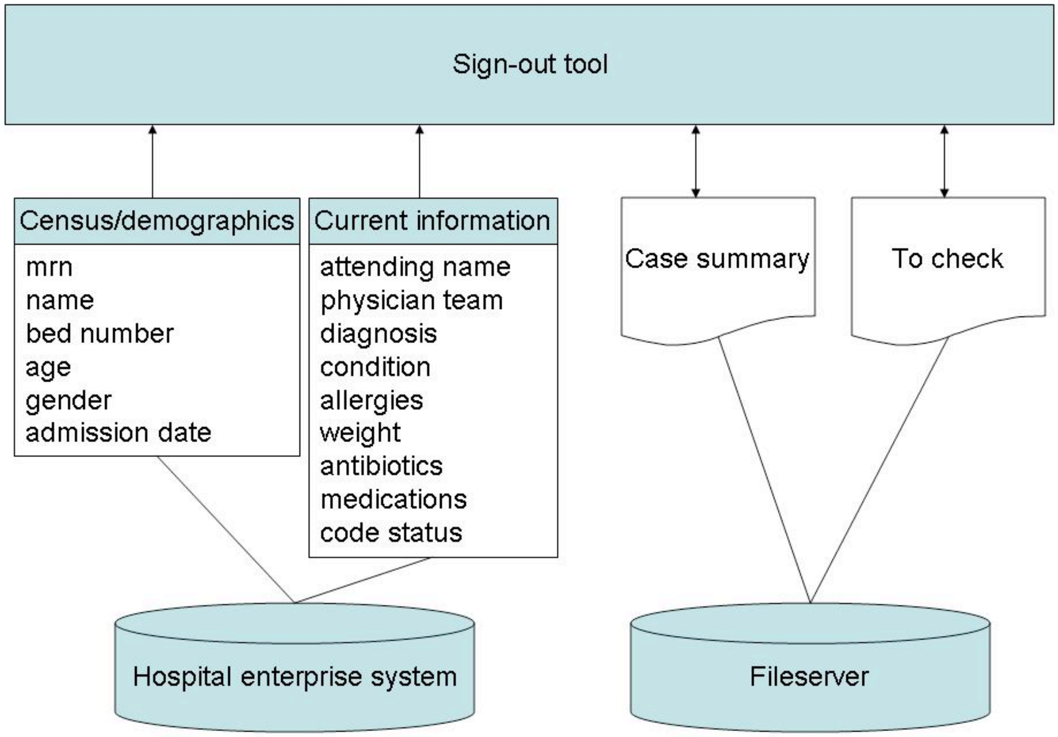

Figure 5. Legacy sign-out tool architecture

Legal issues

Unlike all other clinical documents, sign-out notes are not considered to be part of the legal electronic medical record. The legal exemption encourages physicians to candidly express concerns about patients so that covering physicians can discern quickly the demands of a situation. Because sign-out notes are not part of the legal medical record, they are not accessible via a patient's electronic medical record.

Changing landscape

When the sign-out application was designed and implemented in 1997, informatics tools available to Vanderbilt clinicians were different than today. Many clinical documentation tasks occurred in the care provider order entry system [48] rather than in the electronic medical record application as they do now. Observation of Vanderbilt clinical workflow shows that new informatics initiatives have resulted in duplicative data entry and storage. Adaptations to clinical workflow brought on by new medical procedures and clinical systems result in changes to the ways clinicians record, retrieve, and process information [49]. The sign-out tool exists in the context of information systems that did not exist when it was first developed, such as StarPanel. Evaluating and adjusting sign-out tool functionality to today's clinical and informatics environment is necessary.

CHAPTER IV

RESEARCH PHASES

Research occurred in three phases: preliminary sign-out note content analysis; development and implementation of a replacement sign-out tool to collect data for effective content analysis and to identify features for a new sign-out tool; and assessment of the content produced by users of a sign-out tool. For each phase, the researcher presents a separate subchapter containing methods, results, and discussion.

Phase 1: Preliminary sign-out note content analysis

Background

The researcher sought to develop an understanding of the content of sign-out notes written by clinician users in order to identify new software features to improve provider-to-provider communication. Specifically, the researcher was interested in which data elements, if any, were commonly entered by clinicians in sign-out notes, as well as trends, discrepancies, and patterns in the notes.

Methods

To examine the notes, the researcher recruited two physicians to review 150 randomly selected sign-out notes (one note per patient). The researcher obtained 300 note files (150 "case summary" and 150 "to check" files linked by medical record number) from the WizOrder log files and prepared printouts that consisted of a "case summary" followed by a "to check." Only information saved to the WizOrder log files was used. Other information presented by the sign-out tool for each patient ("current information", patient name, medical record number, case number, unit, or bed number) was not obtained because it was not saved to the WizOrder sign-out log files or any other logs. The researcher instructed the physician reviewers to attempt to identify trends, patterns, discrepancies, etc. in the notes.

Results

Physicians reported many notes containing patient disposition information, noting that the sample of notes probably included a disproportionate number of notes from the last day of a hospitalization. The reviewers observed style differences in the construction of "case summary" sections. Some notes were rambling narratives while others appeared to be copied-and-pasted from structured clinical documents found in the electronic medical record. The reviewers observed a tendency toward abbreviation, acronyms, and short, choppy sentences. Occasionally physicians found the notes to be ambiguous because of style and content. The physicians noted it was fairly obvious on which service patients were admitted because of cues in the sign-out notes, although in some cases the reviewers were unsure.

Discussion

Physicians ruled that the study did not provide much insight into provider-to-provider communication at sign-out because notes were viewed in isolation of other notes from the rest of a patient's hospitalization, and because data identifying the unit and provider caring for a patient was not available. To evaluate the content of sign-out notes, physicians said they required all sign-out notes for a patient's hospitalization presented in chronological order.

Phase 2: Development and implementation of a replacement sign-out tool

Background

The existing sign-out tool's data storage mechanism prevented saving all notes from a patient's hospitalization accurately because the text files on the file server were overwritten each time a user saved updates. As a result, notes could not be presented chronologically for research purposes. Using an external server process to archive sign-out note files at specific times during the day, thereby producing a "snapshot," would create an artificial history of sign-out note content because not all copies of notes would be indicative of user action. Changing the current (legacy) sign-out code to use a different storage medium (i.e. a database) was identified as an option.

The researcher was also interested in identifying and creating new data capture and presentation methods for sign-out software to potentially improve provider-to-provider communication. A priority of the WizOrder development team was to develop new functionality using web-based formats as opposed to desktop applications because a web-based sign-out tool would be accessible independent of WizOrder and could be integrated with other web applications. This functionality was not possible using the existing tool embedded in WizSTAT. Another potential benefit of integration with

StarPanel and other web-based applications concerned the institutional initiative to create "electronic inpatient whiteboards," and certain researchers considered sign-out data as potentially useful toward these goals. Developing a new web-based client would provide an avenue for feedback with users concerning new features for sign-out software.

Methods

Developing and implementing a replacement tool

Because the current (legacy) sign-out tool did not manage data in a way that was amenable to the study of provider-to-provider communication at shift change, the researcher developed, tested, and implemented a replacement tool to better capture patient data and user behavior. The replacement consisted of two parts: 1) backend scripts and a database for storing sign-out information, and 2) a new web-based client to serve as a "drawing board" for new features and system integration.

Using the PHP programming language, Apache web server, and MySQL database software, the researcher developed a method for recording sign-out notes, patient demographics, and user identification to a database each time a user prints or saves a patient's sign-out record. When a user updates an existing sign-out note, the existing note is copied to another table for historical analysis before the new changes are saved. Users are unaware of the archival of sign-out notes. Figure 6 shows the database design of the solution, which includes an inpatient census useful to the web-based client that is discussed below.

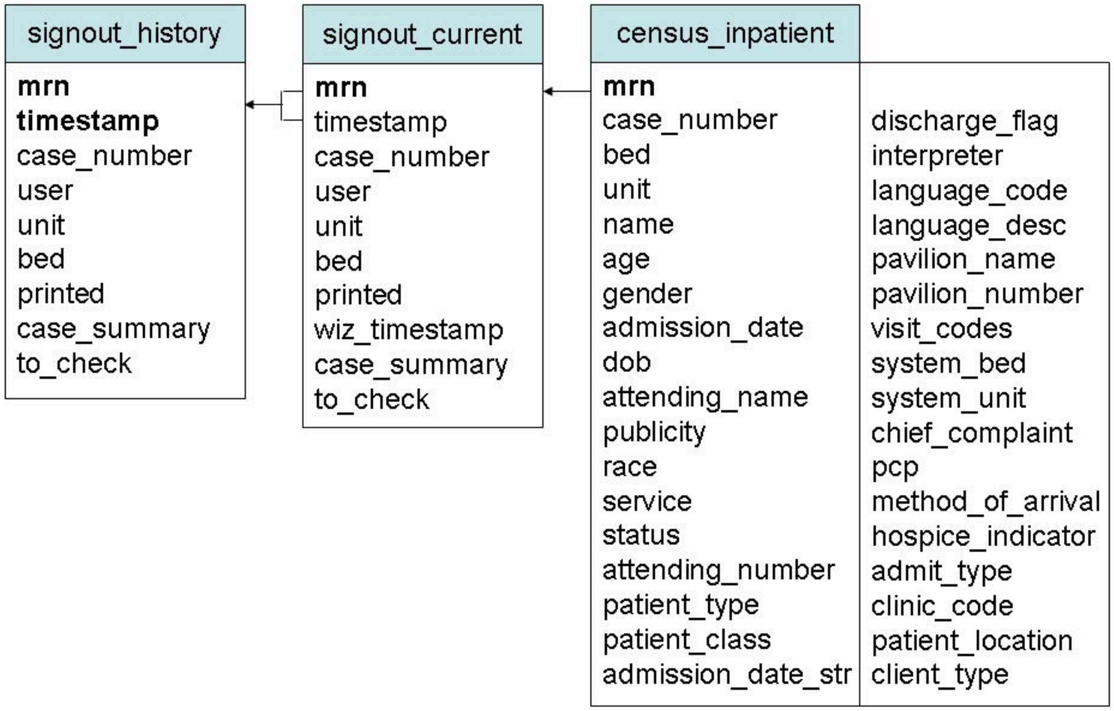

Figure 6. Database design with primary keys indicated in bold

The replacement web-based client was designed to emulate the existing tool's appearance and functionality in order to minimize training and changes in user behavior. As shown in Figure 7, the replacement tool replicates the existing Java tool's functionality by providing access to the new tool through the same WizSTAT screen, mimicking the existing Java interface using a web-based form, and enabling users to create, retrieve, update, and print sign-out notes for patients. The primary difference is that the tool is launched via a web-browser rather than within WizSTAT. Rather than parse the census file from the hospital interface engine each time a user accesses the sign-out tool (as in the existing tool), the replacement tool obtains census information and patient demographics from a database that is updated every five minutes by an external process. To maintain synchronization with the existing sign-out tool during development, the replacement tool saves updates to both the database and the file server used by the existing sign-out tool, as depicted in Figure 8.

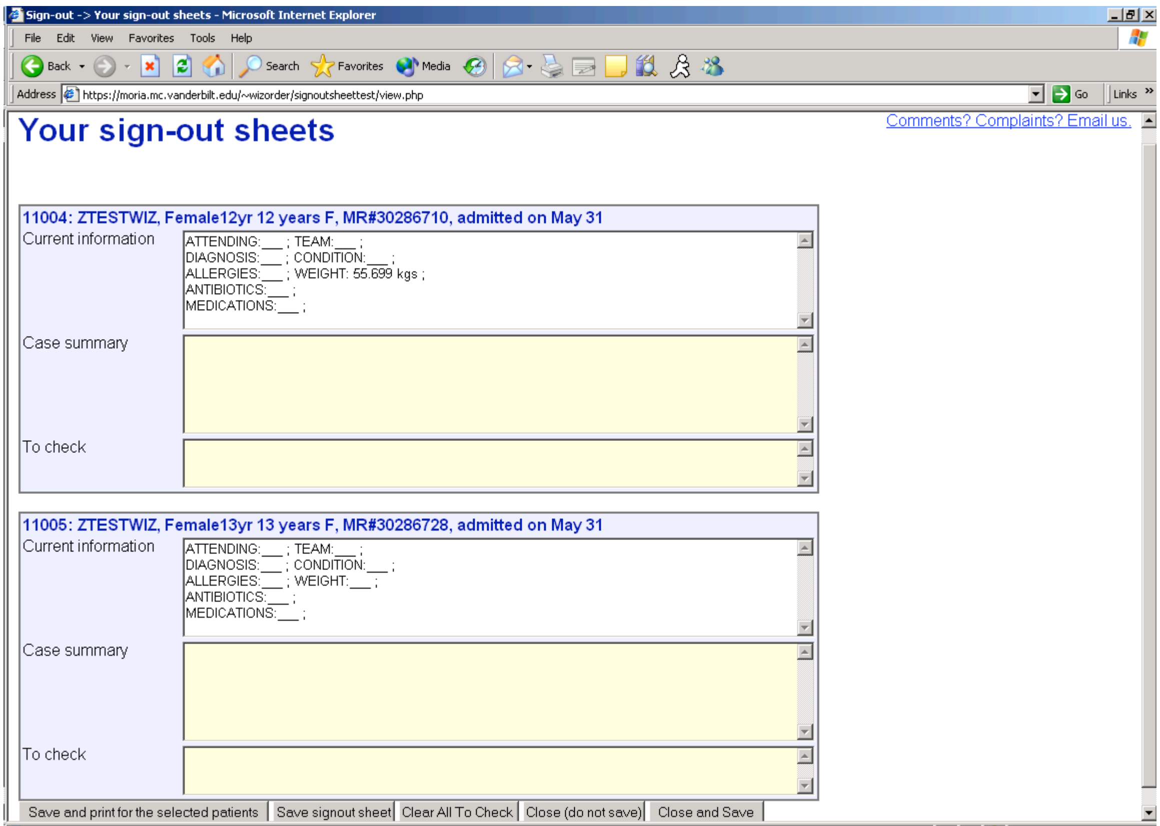

Figure 7. Replacement sign-out tool

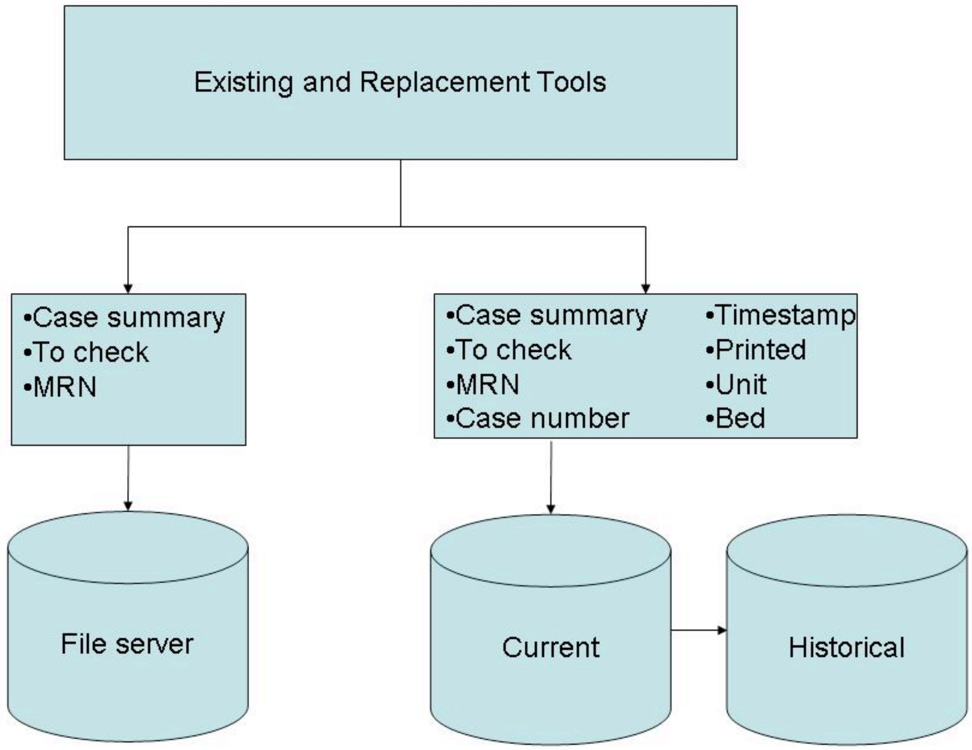

Figure 8. Data storing procedure

After programming and testing prototypes, the researcher collaborated with the WizOrder development team to make the software available to all users in the hospital on August 1, 2006. Despite efforts to port all aspects of the old sign-out tool to the replacement version, technological incompatibilities between WizOrder and web browsers prevented the use of the legacy tool's printing mechanism. Instead the replacement tool utilizes the institution's mainframe printing infrastructure, which offers limited page formatting options. To ease the transition from the legacy tool to the new tool, the development team gave users the option of using either the existing tool or the replacement tool via a popup window when users attempted to access the sign-out tool.

Collecting user feedback

The researcher regularly attended bi-weekly feedback lunch conferences facilitated by the WizOrder development team and sponsored by the Informatics Center to discuss issues with resident physician users. The researcher obtained feedback from users regarding functionality of the replacement sign-out tool and opportunities for new feature development. Using an email link within the sign-out application, users contacted the researcher directly with their concerns.

Results

Implementation

Database storage permitted the chronological analysis of sign-out data. Users' positive reception of the replacement sign-out tool client resulted in the WizOrder development team deciding to make the replacement sign-out tool a permanent part of the clinical informatics environment. The researcher collaborated with the development team to maintain the production software. However, some users preferred the print formatting of the existing sign-out tool, and the WizOrder development team continued to make the existing sign-out tool accessible. Table 2 shows the printing and saving volume of lists of sign-out notes processed by users from 09/29/2006 to 12/31/2006. The range of dates compares to the period of sign-out note data collection, 09/01/2006 to 12/31/2006. However, collection of printing and saving statistics did not begin until 09/29/2006.

Table 2. Printing and saving of new and old sign-out tools

	Total	Print	Save
Replacement	18611 (57.06%)	6643 (56.57%)	11968 (57.33%)
Existing	14008 (42.94%)	5101 (43.43%)	8907 (42.67%)
Total	32619	11744	20875

User feedback

After collecting user reactions through conferences and email, the author categorized feedback into four categories: operational, print formatting, content, and process. Table 3 presents operational and print formatting problems.

Table 3: Operational and print formatting issues

Type	Issue	Resolution
Operational	Inaccurate medication information	Trivial programming fix
Operational	Failure to print	Advise users to print using old tool
Operational	Inaccurate patient census	Ongoing debugging
Print formatting	Limited font, spacing, and margin options for printouts using print subsystem	Advise users to print using old tool

Aside from improved print formatting, new print-oriented features requested by users included a separate printout containing only demographics and "to check" sections grouped by patient, an option to order patients on screen and on printouts by bed number or patient's last name, and the ability to print without saving changes.

Content feedback included identifying sign-out note editors, copying information from the electronic medical record and pasting in sign-out notes, and capturing sign-out data using templates. Users indicated a desire to determine the identity of authors of sign-out notes in order to discuss note content with the authors. Users in some hospital units discussed how they copy and paste content from electronic medical record documents, such as history and physical and assessment and plan notes, to either “case summary” or “to check” sections of sign-out notes, and expressed interest in automating the process. Users suggested adding additional text boxes to the current sign-out interface template, such as “primary care provider,” “pertinent past medical history,” and “pertinent in-hospital medical history.” One OB/GYN resident opined, “A templated (sic) or standardized way of recording sign-out data would help physicians who are new or don’t work here often to sign-out the way they’re supposed to.” Table 4 summarizes new features identified by users.

Table 4: New sign-out tool features identified by users

Type	Features
Print	Separate printout containing only demographics and “to check” sections grouped by patient
Print	Option to order patients on screen and on printouts by bed number or patient’s last name,
Print	Print without saving changes
Content	Determine the identity of authors of sign-out notes
Content	Automate transfer to sign-out notes from other electronic sources that users commonly copy-and-paste
Content	Add additional text boxes to current sign-out interface template

Process feedback involved resident training, the use of the sign-out printout as a “shadow chart,” and physician unawareness of non-physician use of sign-out tool data. Residents suggested that the institution’s StarPanel and WizOrder training sessions are too general and do not emphasize the importance and specific nature of the handoff process and sign-out tool use in each unit or service. Instead residents are left to “figure it out when you get there,” as one resident reported. Some providers indicated they use the sign-out printout as a “shadow chart” to quickly gather data and make decisions when questions arise about patients in their care. After the author reported to a small sample of physicians the statistics of sign-out tool use by non-physician users, the physicians said they were unaware that non-physicians viewed and printed their sign-out note content.

Discussion

Replacing an existing sign-out tool with a web-based sign-out tool assisted data collection and identification of new features for sign-out. The researcher believes user behavior is the same using the new tool and the old tool, and that there is no evidence of the Hawthorne effect [50]. The data collected met the requirements for content analysis examination determined in Phase 1 of this research.

Printing and saving statistics show that the new sign-out tool handled greater volume than the old sign-out tool, a finding which suggests users prefer the web-based version to its legacy equivalent. However, printing and census up-time must be resolved before the legacy tool can be phased out completely. The author discovered that the mainframe printing system's centralized mapping of clinical workstations to printers was not accurate and caused print jobs from the replacement sign-out tool to fail. To correct the mapping problems, considerable effort from another department would have been required, which was determined to be beyond the needs and authority of this research project.

Complaints about printing show clinicians' preference and need for hard copies of sign-out information. The sign-out "shadow chart" provides a portable patient information source and note-taking surface that is vital to clinical workflow. Complaints about the new sign-out tool's printing highlight the importance of sign-out information in clinical workflow.

A printing solution that combines satisfactory page layout and ubiquitous printing ability in VUMC hospitals can eliminate the need for the legacy tool to be in use. PDF and PostScript file creation are two of the printing options identified. Because print formatting affects the ease with which clinicians can identify patient information on paper, thoughtful consideration must be taken when designing the page layout of sign-out tool printouts.

Content issues suggest features to add to new sign-out software. Sign-out tool users should be able to identify the last author of a sign-out note so that clinicians can direct questions about note content to the appropriate party. With the replacement sign-out tool's "history" database table, users can possibly view all changes during a patient's hospitalization. The versioning history of sign-out notes is akin to updates to progress notes in an electronic medical record. In this sense, one can make a case that aggregating sign-out notes in the same way all clinical documents are aggregated in the electronic medical record would be helpful.

The copy-and-paste of data from the electronic medical record to sign-out notes and template-based data capture warrant further investigation. User behavior suggests an overlap in some units or services of clinical documentation and sign-out note authoring. Automated note retrieval can potentially reduce time spent authoring sign-out notes and reduce erroneous copying and pasting. Revising the sign-out template to increase the number of users input fields from two ("case summary" and "to check") presents an opportunity to capture sign-out data in a more discrete and more standardized fashion.

Phase 3: Assessment of sign-out tool usage

After designing and implementing a new sign-out tool to capture sign-out content and related information, the researcher examined the data collected from 09/01/2006 to 12/31/2006 to evaluate provider-to-provider communication at sign-out. The researcher determined descriptive statistics of sign-out tool usage and analyzed content of sign-out notes.

Part A: Descriptive statistics of software utilization

Background

In addition to facilitating the analysis of content, the database-driven replacement sign-out tool permitted the evaluation of user behavior. The researcher was interested in providers' use of the tool. No internal or published evaluation of Vanderbilt sign-out tool usage exists. Basic statistics of sign-out note generation and printing exist in at least one study [31], but sign-out tool use has not been investigated comprehensively. The researcher tested three hypotheses in the experiments:

Hypothesis 1_0: Providers generate sign-out notes.

Hypothesis 2_0: Providers print sign-out notes.

Hypothesis 3_0: Sign-out tool utilization is similar across units/services.

Methods

The researcher examined sign-out tool utilization in terms of generation and printing of sign-out notes according to hospital unit, provider role, and time of day. A sign-out note is defined as a database record for a patient saved by a provider at a specific time containing both a “case summary” and “to check” section. “Case summary” and “to check” sections may be null or non-null. Each sign-out note is identified by its patient's medical record number and timestamp of creation. A sign-out note is unique if either the “case summary” or “to check” is non-null, and the text of either the “case summary” or “to check” differs from the preceding record of a patient's hospitalization or is the first record of a patient's hospitalization containing a non-null “case summary” and/or “to check.” A sign-out note is printed if its database record indicates a user printed it.

The researcher used the WizOrder orders and staff authorization databases to cross reference user ID’s to determine provider roles. Users included attending physicians, resident physicians, medical students, nurse practitioners, nurses, case managers, medical receptionists/care partners, and others, which included social workers, respiratory therapists, dietitians, and unspecified ancillaries.

To provide an estimate of a unit/service’s patient volume, the researcher used the WizOrder order history database to determine the number of patients for which each unit entered an order. Average length of stay (LOS) for patients on each unit was determined by examining the order history database for only patients admitted and discharged within the study period. Linear regression was performed using SPSS [51].

Results

Users created 232,963 total sign-out notes for 13,519 unique patients, or 59.51% of patients admitted to the hospital during the study period. Possible explanations for this figure are provided in the Discussion. Of the total notes, 22% (52,560) were unique. Users printed 108,660 notes, or 46% of the total notes.

Table 5 shows an estimate of sign-out tool workflow importance based on the ratio of unique sign-out cases to unique order cases in each unit/service. The shaded row of cells represents the median. A case is a unique order case for a unit/service if that unit/service entered an order for that case. A percentage near 100% suggests sign-out is a frequent part of a unit/service's workflow. Units/services with high levels of sign-out activity (i.e. above the median) represented a variety of specializations, namely adult medicine, pediatrics, and neonatal intensive care, while surgery and emergency/observation units generally had low levels of sign-out activity (i.e. below the median). Neonatal intensive care's estimate exceeds 100% because patients may transfer into a subunit without receiving any new orders.

Table 5: Estimated sign-out tool workflow importance

Unit/service	Sign-out/ order cases	Sign-out cases	Order cases
Neonatal ICU	102.20%	651	637
Trauma ICU	99.87%	787	788
Pediatric medicine	99.35%	1366	1375
Neuro ICU	97.47%	463	475
Renal	96.93%	536	553
Pediatric cardiology	96.64%	316	327
Adult medicine	96.12%	1485	1545
Adult neurology	95.74%	921	962
Medical ICU	95.54%	557	583
Pediatric critical care	90.03%	650	722
Adult myelosuppression	89.44%	322	360
Post partum	86.13%	1254	1456
Pediatric myelosuppression	84.95%	175	206
Pediatric hematology/oncology	82.19%	323	393
Adolescent medicine	79.39%	339	427
Cardiology	78.08%	1596	2044
Pediatric neurology	77.97%	223	286
Normal nursery	76.96%	735	955
Stallman nurseries	62.37%	121	194
Subacute	54.10%	178	329
Adult medicine round wing	47.83%	154	322
Neurosurgery	45.86%	244	532
Adolescent surgery	45.12%	236	523
Pediatric surgery	45.09%	216	479
Labor & delivery	40.62%	580	1428
Cardiac ICU	39.82%	264	663
Cardiac catheterization lab	35.15%	581	1653
Adult observation	33.78%	175	518
Women's surgery	31.02%	318	1025
Surgical ICU	30.60%	123	402
Pediatric observation	27.42%	156	569
Surgical stepdown	25.89%	196	757
Pediatric OR	22.33%	336	1505
General surgery	16.49%	172	1043
Orthopaedics	14.23%	453	3183
Dialysis	15.28%	99	648
Adult emergency department	14.40%	733	5091
Adult operating room	14.23%	453	3183
Pediatric emergency	6.71%	196	2920

Table 6 shows the average number of unique sign-out notes generated per sign-out case in each unit/service. The shaded row of cells represents the median. To provide a basis of comparison against a unit's total order volume, the average number of unique sign-out notes generated per order case is provided. Average length of stay based only on patients admitted and discharged is also presented. High sign-out note to sign-out note case averages (i.e. above the median) were seen in neonatal intensive care, pediatric and adult myelosuppression, pediatric units, adult medicine units, and two surgery units, while low averages (i.e. below the median) were seen mostly in all other surgery and emergency/observation units. Post partum is the only unit that appears to generate at least one note per day of a patient case.

Table 6: Average number of unique notes generated per sign-out case

Unit/service	Unique sign-out notes/sign-out cases	Unique sign-out notes/order cases	Unique sign-out/ LOS	Average length of stay (days)	Unique sign-out notes
Neonatal ICU	9.28	9.28	0.48	19.36	6042
Adult myelosuppression	7.44	6.66	0.80	9.35	2396
Pediatric myelosuppression	7.09	6.02	0.94	7.52	1240
Post partum	5.41	4.66	1.59	3.40	6782
Pediatric critical care	4.72	4.25	0.62	7.66	3068
Pediatric cardiology	4.47	4.31	0.65	6.82	1411
Pediatric hematology/oncology	3.66	3.01	0.66	5.52	1183
Surgical stepdown	3.40	0.88	0.35	9.73	667
Adult medicine round wing	3.20	1.53	0.47	6.79	493
Pediatric medicine	3.14	3.12	0.74	4.26	4287
Adolescent medicine	2.96	2.35	0.67	4.44	1003
Adult medicine	2.81	2.71	0.44	6.33	4180
Women's surgery	2.75	0.85	0.85	3.25	876
Pediatric neurology	2.42	1.89	0.61	3.99	540
Subacute	2.42	1.31	0.41	5.93	431
Normal nursery	2.23	1.72	0.82	2.72	1638
Cardiology	2.20	1.72	0.51	4.29	3518
Neuro ICU	2.17	2.11	0.36	5.96	1004
Dialysis	1.88	0.29	0.21	9.15	186
Pediatric surgery	1.84	0.83	0.41	4.45	398
Renal	1.82	1.76	0.36	5.03	974
Labor & delivery	1.80	0.73	0.52	3.46	1042
Neurosurgery	1.61	0.74	0.16	10.36	394
Trauma ICU	1.56	1.56	0.23	6.83	1230
Surgical ICU	1.46	0.45	0.09	16.78	180
Adolescent surgery	1.41	0.63	0.30	4.74	332
General surgery	1.39	0.23	0.18	7.76	239
Adult emergency department	1.33	0.19	0.28	4.70	974
Medical ICU	1.27	1.21	0.15	8.18	705
Adult observation	1.25	0.42	0.46	2.72	219
Neurology	1.24	1.19	0.26	4.82	1140
Cardiac catheterization Lab	1.23	0.43	0.50	2.44	714
Pediatric observation	1.18	0.32	0.45	2.63	184
Stallman nurseries	1.16	0.72	0.07	17.14	140
Cardiac ICU	1.11	0.44	0.15	7.48	294
Orthopaedics	1.09	0.15	0.14	7.64	493
Adult operating room	1.09	0.15	0.23	4.68	493
Pediatric emergency	0.80	0.05	0.22	3.66	156
Pediatric operating room	0.44	0.10	0.07	6.20	147

As shown in Figure 9, linear regression of units' average length of stay to units' unique notes generated per patient yielded an r^2 correlation of 0.116. Units' unique notes generated per patient and average length of stay do not appear linearly independent according to a one-way analysis of variance ($F = 4.853$, $p = 0.034$). Data points in Figure 9 represent individual units.

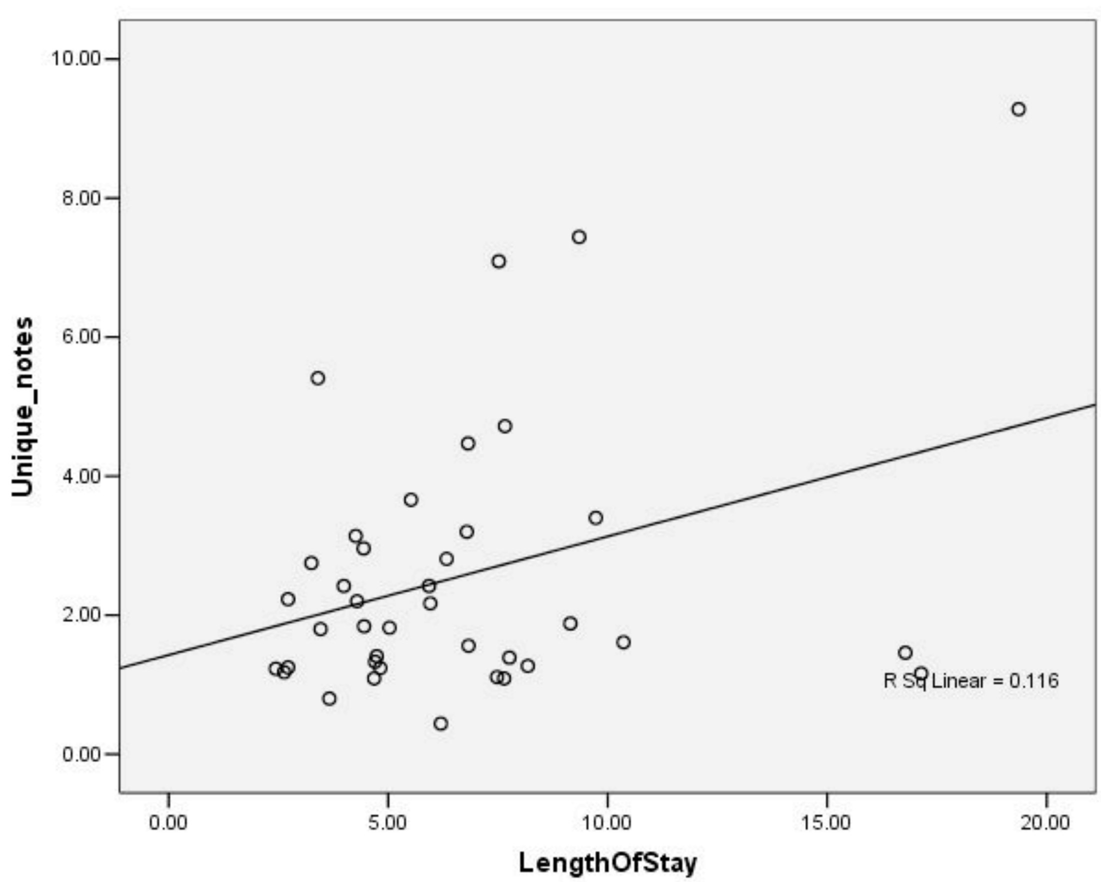

Figure 9. Scatter plot of unique note generation and average length of stay

Table 7 shows the average number of notes printed per sign-out case in each unit/service. The shaded row of cells represents the median. The printing of notes includes unique and non-unique notes. The ratio of notes printed to order cases is also presented to provide a baseline for comparison. Average length of stay based only on patients admitted and discharged is also presented. Intensive care units accounted for four of the top five highest averages. Pediatric units, adult medicine, and surgical stepdown also had high printing levels (i.e. above the median). Low printing levels (i.e. below the median) were seen mostly in surgical units and emergency/observation. Based on the estimate of notes printed per order case to average length of stay, most units printed notes for an individual patient less than one time per day.

Table 7: Average number of notes printed per sign-out case

Unit/service	Printed/ sign-out cases	Printed/ order cases	Printed sign-out/ LOS	Average length of stay (days)	Printed
Medical ICU	14.46	13.81	1.77	8.18	8052
Trauma ICU	13.32	13.30	1.95	6.83	10484
Neonatal ICU	12.01	12.27	0.62	19.36	7817
Neuro ICU	9.64	9.40	1.62	5.96	4464
Pediatric cardiology	9.56	9.24	1.40	6.82	3021
Renal	9.00	8.72	1.79	5.03	4824
Adult medicine	8.71	8.37	1.38	6.33	12931
Post partum	7.26	6.25	2.13	3.40	9103
Neurology	7.14	6.83	1.48	4.82	6575
Adult myelosuppression	7.08	6.33	0.76	9.35	2279
Pediatric critical care	6.86	6.17	0.90	7.66	4456
Cardiology	6.27	4.90	1.46	4.29	10007
Pediatric myelosuppression	5.90	5.01	0.79	7.52	1033
Surgical stepdown	5.47	1.42	0.56	9.73	1072
Neurosurgery	5.27	2.42	0.51	10.36	1285
Stallman nurseries	5.17	3.23	0.30	17.14	626
Pediatric medicine	4.02	4.00	0.94	4.26	5498
Adult medicine round wing	3.62	1.73	0.53	6.79	557
Surgical ICU	3.58	1.09	0.21	16.78	440
Normal nursery	3.47	2.67	1.28	2.72	2552
Adolescent medicine	3.31	2.63	0.74	4.44	1121
Pediatric hematology/oncology	3.14	2.58	0.57	5.52	1013
General surgery	2.64	0.44	0.34	7.76	454
Pediatric surgery	2.61	1.18	0.59	4.45	563
Adolescent surgery	2.59	1.17	0.55	4.74	611
Pediatric neurology	2.49	1.94	0.62	3.99	555
Subacute	2.44	1.32	0.41	5.93	434
Cardiac ICU	2.01	0.80	0.27	7.48	531
Dialysis	1.40	0.21	0.15	9.15	139
Adult observation	1.35	0.46	0.50	2.72	236
Women's surgery	1.31	0.41	0.40	3.25	417
Adult emergency department	1.26	0.18	0.27	4.70	925
Pediatric operating room	1.20	0.27	0.19	6.20	402
Cardiac catheterization lab	1.12	0.39	0.46	2.44	648
Orthopaedics	1.11	0.16	0.15	7.64	504
Adult operating room	1.11	0.16	0.24	4.68	504
Pediatric observation	1.10	0.30	0.42	2.63	171
Labor & delivery	1.05	0.43	0.30	3.46	607
Pediatric emergency	1.02	0.07	0.28	3.66	200

To better understand the dynamic nature of printed sign-out content, the researcher developed the concept of "freshness," an estimate of how frequently printouts contain up-to-date sign-out information. The ratio of unique note generation to printing for each unit, as presented in Table 8, shows the "freshness" of printed sign-out content. The shaded row of cells represents the median. Units with ratios greater than one produced more notes than they printed, which suggests that printout content in these units is always up-to-date. Across units/services there was variation in how often users printed up-to-date content.

Table 8: Comparison of sign-out note "freshness"

Unit/service	"Freshness"	Unique notes	Printed notes	Unique notes per case/LOS	Average length of stay (days)
Women's surgery	2.10	876	417	0.85	3.25
Labor & delivery	1.72	1042	607	0.52	3.46
Dialysis	1.34	186	139	0.21	9.15
Pediatric myelosuppression	1.20	1240	1033	0.94	7.52
Pediatric hematology/oncology	1.17	1183	1013	0.66	5.52
Cardiac catheterization lab	1.10	714	648	0.50	2.44
Pediatric observation	1.08	184	171	0.45	2.63
Adult emergency department	1.05	974	925	0.28	4.70
Adult myelosuppression	1.05	2396	2279	0.80	9.35
Subacute	0.99	431	434	0.41	5.93
Adult operating room	0.98	493	504	0.14	7.64
Orthopaedics	0.98	493	504	0.23	4.68
Pediatric neurology	0.97	540	555	0.61	3.99
Adult observation	0.93	219	236	0.46	2.72
Adolescent medicine	0.89	1003	1121	0.67	4.44
Adult medicine round wing	0.89	493	557	0.47	6.79
Pediatric emergency	0.78	156	200	0.22	3.66
Pediatric medicine	0.78	4287	5498	0.74	4.26
Neonatal ICU	0.77	6042	7817	0.48	19.36
Post partum	0.75	6782	9103	1.59	3.40
Pediatric surgery	0.71	398	563	0.41	4.45
Pediatric critical care	0.69	3068	4456	0.62	7.66
Normal nursery	0.64	1638	2552	0.82	2.72
Surgical stepdown	0.62	667	1072	0.35	9.73
Cardiac ICU	0.55	294	531	0.15	7.48
Adolescent surgery	0.54	332	611	0.30	4.74
General surgery	0.53	239	454	0.18	7.76
Pediatric cardiology	0.47	1411	3021	0.65	6.82
Surgical ICU	0.41	180	440	0.09	16.78
Pediatric operating room	0.37	147	402	0.07	6.20
Cardiology	0.35	3518	10007	0.51	4.29
Adult medicine	0.32	4180	12931	0.44	6.33
Neurosurgery	0.31	394	1285	0.16	10.36
Neuro ICU	0.22	1004	4464	0.36	5.96
Stallman nurseries	0.22	140	626	0.07	17.14
Renal	0.20	974	4824	0.36	5.03
Neurology	0.17	1140	6575	0.26	4.82
Trauma ICU	0.12	1230	10484	0.23	6.83
Medical ICU	0.09	705	8052	0.15	8.18

As shown in Figure 10, linear regression of average length of stay to units' printed notes per patient yielded an r^2 correlation of 0.128. A one-way analysis of variance shows the two variables are not linearly independent ($F = 5.40$, $p = 0.025$). Data points in Figure 10 represent individual units.

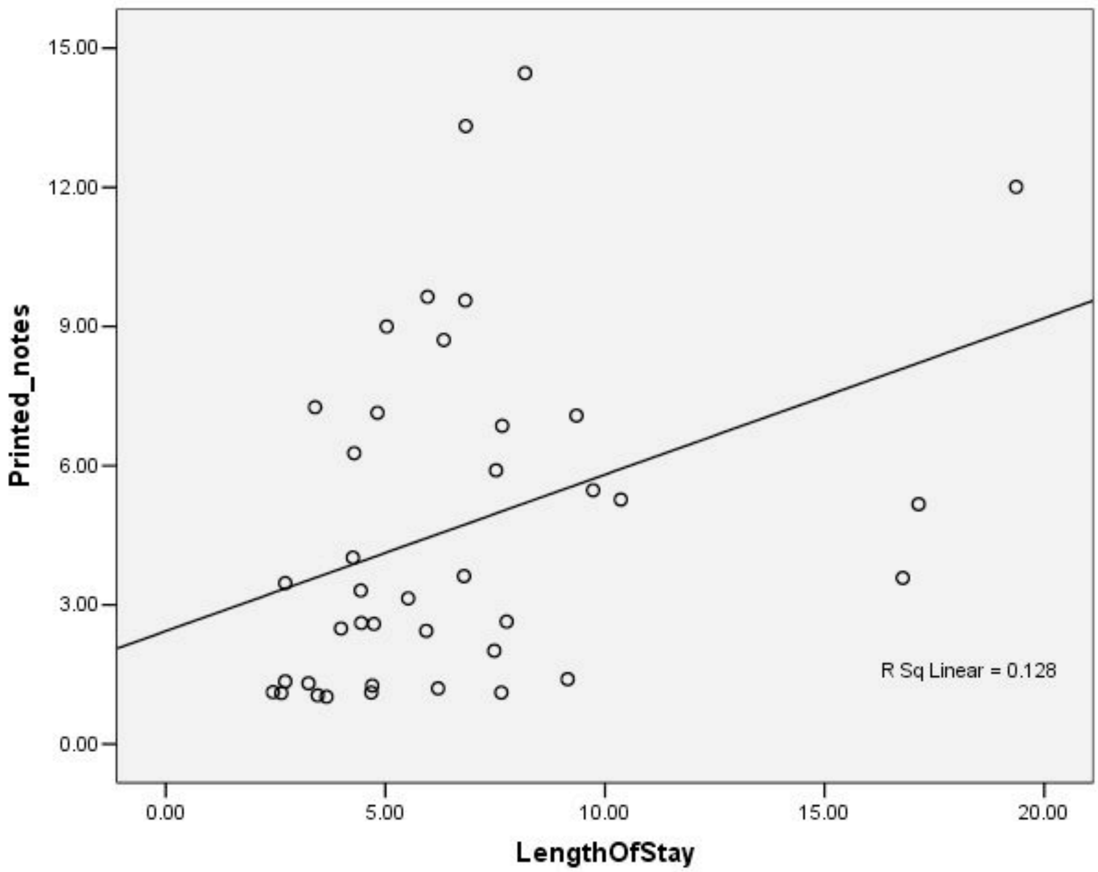

Figure 10. Scatter plot showing units' printed notes to average length of stay

Users in the sign-out database were cross-referenced with a staff authorization database to determine their professional role. Figure 11 shows the unique sign-out notes generated and printed by role, and Table 9 shows numerical totals of each role's activity.

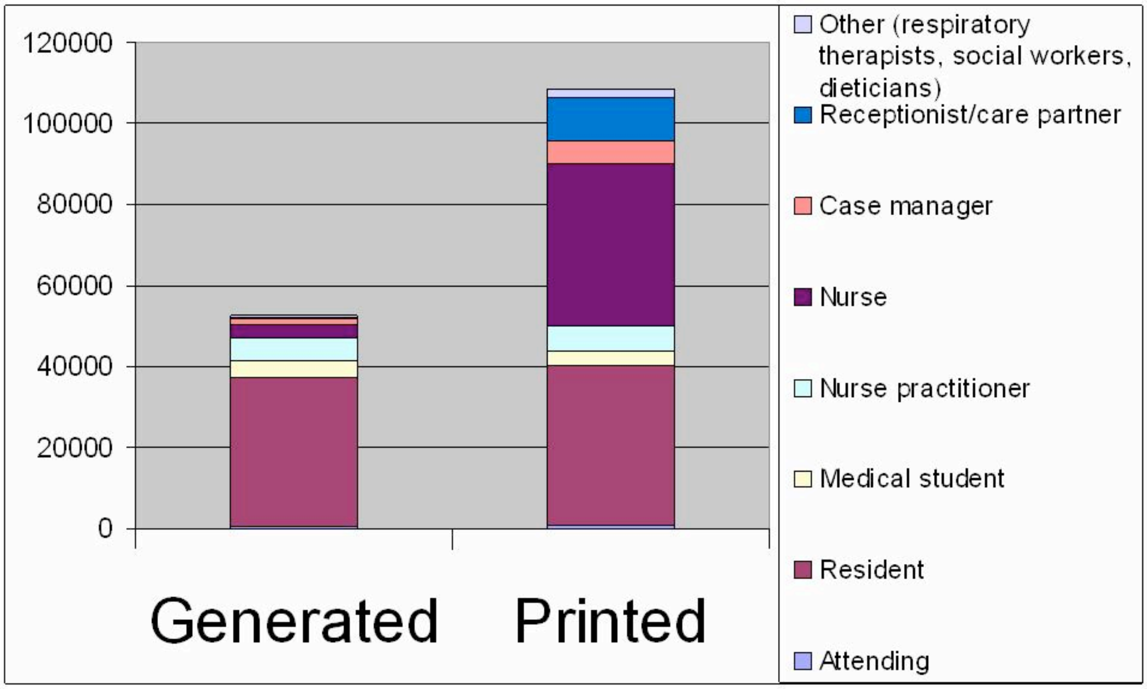

Figure 11. Note generating and printing by role

Table 9. Unique notes generated and total notes printed by professional role

	Generated	Printed
Attending	327	528
Resident	37012	39594
Medical student	3987	3563
Nurse practitioner	5917	6411
Nurse	3127	40117
Case manager	1618	5491
Medical receptionist/care partner	372	10560
Other	200	2396

Figure 12 shows the time of day when resident physicians and nurse practitioners generated unique notes and resident physicians, nurse practitioners, nurses, medical receptionist/care partners, and case managers printed notes. Resident physicians unique note generation was highest between 11:00 and 13:00; printing levels were slightly below generation levels. From 12:00 to 15:00 resident physicians printed nearly the same number of notes as they generated. Resident physician printing exceeded note generation from 16:00 to 20:00 and again from 04:00 to 09:00. Nurse practitioner generation and printing levels peaked at 06:00 before steadily rising and peaking again at 16:00. Nurse printing was greatest between 04:00 and 06:00 and again between 16:00 and 18:00. Medical receptionist printing peaked at 06:00 and 17:00. Case manager printing was greatest at 07:00.

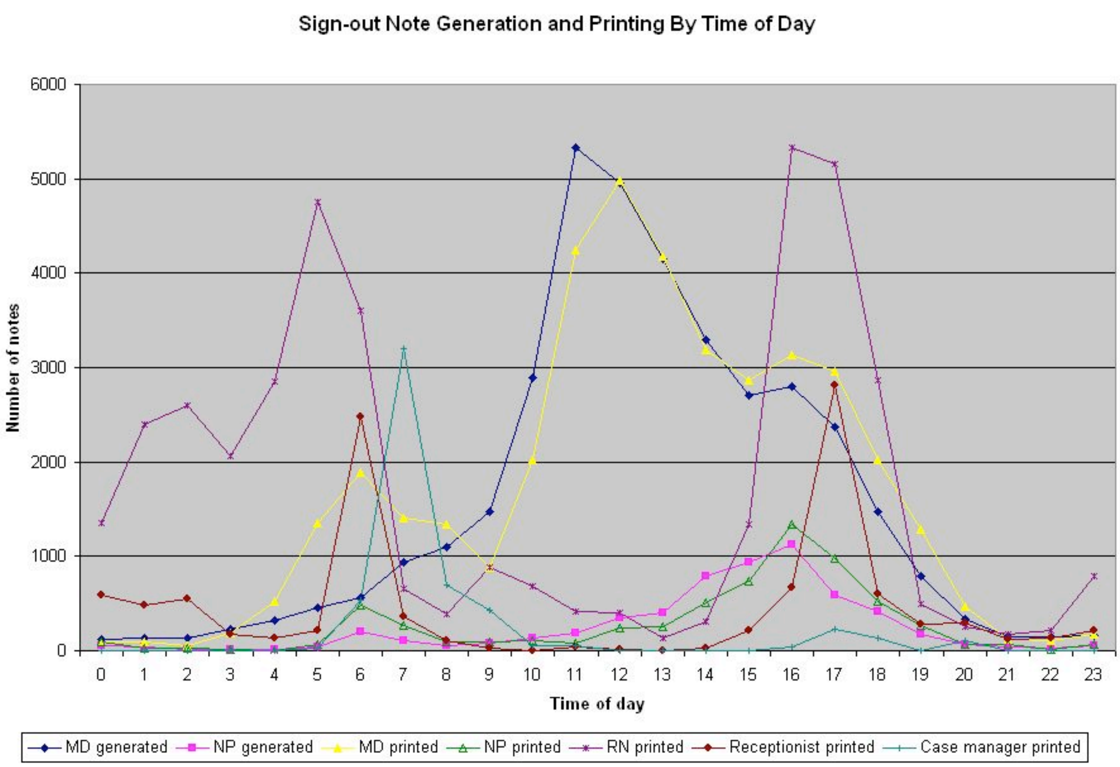

Figure 12. Sign-out note generation and printing by time of day

Discussion

The sign-out tool was designed for the task of "physician sign-out." Identifying a large proportion of non-provider users was unexpected, and led to rejection of null hypotheses 1 and 2. In particular, nurses, case managers, and medical receptionists/care partners were found to have high levels of printing and low levels of unique note generation. Of non-providers, nurses were responsible for printing the most notes on the majority of units. However, notable exceptions to this trend included medical receptionists in medical intensive care printing over 66% of notes and medical receptionists in neurology printing more than 34% of notes. Although non-providers were responsible for low levels of unique sign-out note generation in most units, case managers authored 64% of unique notes in trauma. Consulting with medical intensive care unit personnel revealed that medical receptionists in the unit print sign-out notes for charge nurses. Informal analysis shows that trauma sign-out notes are used exclusively for patient disposition, and that case managers facilitate this process. Additional observations include medical student sign-out activity being limited mostly to obstetrics and gynecology units.

Resident physicians and nurse practitioners authored 90% of notes they printed. In contrast, nurses authored only 8% of the notes they printed, despite printing more notes than residents overall. Proportions of unique note generation and printing were similar to nursing for other non-providers. Since resident physicians and nurse practitioners instantiate medical decisions for a patient's care team, they are responsible for authoring the bulk of patient care directives, including sign-out notes. The difference in contributions and printing for providers and non-providers suggests that providers serve as “producers” and non-providers as “consumers” of sign-out content. Providers might not be aware that their sign-out notes are being used for more than the organization of patient information for cross-cover or night float physicians. Awareness of consumption by non-providers may influence the content of the notes generated by providers.

The peak times for printing shown in Figure 10 coincide with the times of nursing shift change and provider sign-out. Nurses printed sign-out notes between 05:00 and 07:00 and 16:00 and 18:00 in preparation for end-of-shift report to another nurse at 07:00 and 19:00, respectively. Medical receptionists' peak printing hours correspond to nursing shift change as well. Case managers printed mostly in the morning because they do not work a night shift. The peak time of providers printing and generating unique notes was from 11:00 to 13:00. Post-call residents rushing to complete sign-out by 14:00 to comply with work hour regulations might explain this observation. In contrast, nurse practitioners' peak time of sign-out tool activity coincides with evening provider sign-out at 17:00. Nurse practitioners may not have overnight patient care responsibilities and are also not subject to work hour regulations. A spike in resident physician printing levels at 06:00 might correspond to residents preparing for morning rounds.

Providers appear to print notes when they generate them, but nurses, medical receptionists, and case managers have a tendency to print notes several hours after providers generate them. Since providers update their notes predominantly at midday, provider content may no longer be current for those who print in the evening and early morning hours. Although patient status changes are infrequent and/or not documented by the physician responsible at night, the bulk of unique notes are generated in the afternoon. Perhaps nurses could benefit from obtaining and/or printing sign-out information at the same time physicians update sign-out notes.

During a patient's stay the number of average unique notes generated varied from 9.28 (neonatal intensive care) to 0.44 (pediatric operating room), and total notes printed varied from 14.46 (medical intensive care) to 1.02 (pediatric emergency). Variability in note generation and printing was unexpected, leading the researcher to reject null hypothesis 3. The researcher posits that low overall sign-out tool use by surgery and emergency/observation units is largely responsible for 40.49% of hospital admissions/observations not having a sign-out note generated in the study period. These units featured unique sign-out note to order case ratios less than 1.

Length of stay appeared to have a minor influence in the generation and printing of sign-out note content. Linear regression shows that variability in length of stay predicts 11.6% and 12.8% of variability in unique note generation and printing, respectively. Other sources of variability, which might include unit-specific sign-out tool usage patterns, account for almost 90% of variability in both measures. Although the relationship between units' average length of stay and sign-out activity appears statistically significant, more meaningful differences can be found by examining the units from a qualitative standpoint.

Comparing sign-out notes per sign-out case to sign-out notes per order case, as in Table 6, shows the importance of the sign-out tool in managing certain patient cases. For units like neonatal ICU, adult myelosuppression, and pediatric myelosuppression, users manage nearly every patient case with the sign-out tool. For units like surgical stepdown, women's surgery, and dialysis, users manage a fraction of total patient cases using the sign-out tool. However, when these units use the sign-out tool to manage their small numbers of patient cases, the average number of unique notes generated is high compared to other units. Surgical stepdown, women's surgery, and dialysis are also notable for having unique note generation to sign-out case ratios and notes per order case ratios less than one. Although the units do not generate unique sign-out notes as part of their normal workflow, they generate three to six times more notes when they use the sign-out tool. Surgical stepdown and dialysis also have high average length of stay figures, as shown in Table 6, and presumably an increased number of handoffs between providers. Taken together these observations suggest that the sign-out tool is important for a subset of patients in units with low levels of overall sign-out activity.

The highest average number of notes printed per sign-out case occurred in intensive care units—specifically medical, trauma, neonatal, and neurological. The ratios were similar to the average number of notes printed per order case, suggesting that note printing is a common part of workflow in these units. Two other intensive care units—surgical intensive care and cardiac intensive care—did not have similarly high levels of printing activity. Although four intensive care units printed the most notes by volume, three of them, with the exception of neonatal intensive care, were among the bottom six in terms of "freshness." This suggests that medical, trauma, and neurological intensive care units print the same notes repeatedly.

The generation of less than one unique note per patient per day, as shown in Table 6, might seem atypical when it is, in fact, normal. Post partum is the only unit that generates more than one unique note per day (1.59). Several factors influence the generation of sign-out notes: a patient's short stay on a unit; users' failure to update notes; sign-out software not being a normal part of unit workflow; and sign-out note updates not being necessary. For example, a patient admitted to an on-call physician at

22:00 on Monday would have one sign-out note generated at 13:00 on Tuesday before being discharged at 09:00 Wednesday.

Printing a note that has not been previously printed occurs most frequently on units with high levels of "freshness." "Freshness" ratios less than 1.0 are reasonable because many non-providers print the notes generated by providers. Although sign-out content might not be "fresh," it still provides utility to users. Additionally, some users are more interested in the demographic and active order information than user-generated "case summary" and "to check" data. There is not enough evidence to suggest that low levels of "freshness" of printed sign-out content put patients in danger, but awareness of "freshness" of might cause some users to update notes more frequently and other users to print notes less often. "Freshness" figures are limited in that they do not provide consideration for time of printing with respect to patient length of stay.

In this study average length of stay excludes patients admitted before and/or discharged after the study period, which omits patients with long lengths of stay and comparably short periods of sign-out activity (i.e. notes only for beginning or ending of hospitalization are in study period). Average length of stay calculations include 90% of patients from the study period. Ratios of unique note generation and note printing to unique sign-out cases include all patients regardless of admission and discharge date. Although the two sets of measures incorporate study period length differently, the researcher believes they can be compared against each other to provide accurate estimates of sign-out tool usage.

The average LOS figure presented for some units might be misleading. A unique case (sign-out or order) for one unit could be counted as a unique case for another unit if the case was transferred between units. As a result a unit's average length of stay calculation might include time accrued by unique cases in other units before or after transfer. Adult and pediatric emergency/observation, adult and pediatric operating rooms, and the Stallman nurseries exhibit this trait. For example, although pediatric patients who presented in the emergency department and were admitted to a hospital unit might have spent 3.66 days in the hospital on average, it is doubtful the patients spent 3.66 days only in the pediatric emergency department, as reported in the average LOS figures. Additionally, most infants delivered at Vanderbilt University Hospital requiring neonatal intensive care are admitted to the Stallman nurseries adjacent to labor and delivery before being transferred to the neonatal intensive care unit in the Children's Hospital, which is located in a separate facility. With the exception of the previously stated units, all LOS calculations are believed to be reliable estimates.

Limitations of this study include the accuracy of the staff authorization database for identifying users' professional roles and use of an order history database to measure unit/service patient volume and length of stay. Additionally, the staff database's naming convention contains some redundancy and does not identify resident physicians by their post-graduate year. As a result, differentiating between interns and residents was not possible. Although the order history database provides an estimate of a patient's length of stay in the hospital during a hospitalization, the hospital's admission-discharge-transfer system provides the amount of time a patient spends in individual hospital units during a stay, which might be more helpful in examining unit-specific sign-out software usage.

Future study of sign-out will focus on the relationship between two providers involved in a sign-out. Specifically, the researcher will examine whether two providers are on the same patient care team or if the provider receiving on-call responsibility is from another team or is a night float, a status called cross-coverage. Timing, printing, note writing styles, and other aspects of sign-out tool usage and content can be examined.

Part B: Content analysis of sign-out notes

Background

Sign-out is a process related to continuity of care. To date no studies have thoroughly evaluated the qualitative aspects of content produced by users of sign-out software. Examining sign-out note content serves to improve understanding of provider-to-provider communication at shift change and identify ways to better manage sign-out data.

Because little is known about sign-out note content, a research methodology that emphasizes systematic discovery of theory rather than hypothesis testing is appropriate. Grounded theory is one such approach to analyzing large datasets that are not well understood [52]. Strauss and Corbin explain:

> "A grounded theory is one that is inductively derived from the phenomenon it represents. That is, it is discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, data collection, analysis, and theory stand in reciprocal relationship with each other. One does not begin with a theory, then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge."

Although grounded theory favors theory generation over hypothesis testing, differences discovered in Part A of this analysis invite hypothesis testing. Specifically, the difference in care provided by different hospital units implies that there may be differences in the way users in different units generate sign-out note content. In this section, the author uses a modified grounded theory approach to perform a qualitative analysis of the content of notes produced by users of the sign-out tool. The aim is to develop theory on sign-out note content and test the hypothesis:

H_0: Sign-out note content is similar across units/services.

Methods

Sampling

During the study period, users generated sign-out notes for 13,519 inpatient/observation cases. Although the majority of patient cases received care from a single hospital unit, 4,979 cases had notes generated in multiple units/services, a reflection of the number of patients transferred between units/services. Table X shows the number of unique patient cases for which each unit/service generated and/or printed a sign-out note. The researcher reviewed 729 total unique cases from 39 units/services. To obtain a sample of notes sufficient for analysis, the researcher selected 5% (an arbitrary percentage) of the total cases at random based on each unit's percentage of unique cases processed. Each case's unit designation was preserved. The researcher examined a minimum of ten cases per unit to maintain analytic rigor. Units with fewer than 99 cases were excluded from the study.

Grounded theory analysis

Grounded theory researchers employ the "constant comparison method" of data analysis, which consists of three overlapping stages. In "open coding", the ideas, components, and/or phenomena of the body of inquiry are identified as they emerge. Such *ad hoc* categorization is suitable for a task in which theory development is the goal and presuppositions of the dataset are few. In "axial coding," the "focus is on specifying a category (*phenomenon*) in terms of the conditions that give rise to it; the *context* (its specific set of properties) in which it is embedded; the action/interactional *strategies* by which is it handled, managed, carried out; and the *consequences* of those strategies" [52]. In "selective coding," the concepts identified in axial coding are assembled to represent the essence, or "core," that relates all findings. The three stages overlap in how comparisons, identification of concepts, and synthesis of low- and high-level ideas occur simultaneously in the discovery of theory [52].

For each unit/service, the researcher examined the number of patient cases specified in Table X. The researcher reviewed each case's sign-out notes presented in chronological order. A sign-out note consists of the free text "case summary" and "to check" sections along with administrative data including unit/service, user ID who last printed/saved, user ID's professional role, timestamp of print/save, and print status. The researcher performed "open coding" by recording labels and observations of each case in a separate spreadsheet for each unit. When necessary, the researcher examined a patient's electronic medical record to confirm observations. To perform axial and selective coding, the researcher produced paper reports containing numeric totals of categories along with qualitative comments. The researcher compared categories and comments and arranged paper reports as themes emerged, a process called “memoing” [52].

Results

In the analysis three themes emerged: common to all units, specific to “case summary” length, and specific to a unit/service’s care.

Common to all units

The “case summary” section of the sign-out note typically included any combination of a patient’s admission reason, past medical history, assessment and plan, pertinent test results, and recent procedures. The format of “case summary” notes was variable, including terse, code-like statements, brief narrative summaries, lengthy narrative summaries, organ system-based lists, and assorted combinations. Table 10 shows examples of “case summary” note formats. The formats of notes in the “case summary” length classifications varied. Despite the “case summary” section’s varied use, nearly all sign-out notes contained text in the “case summary” section; seldom were blank “case summary” entries observed.

Compared to the “case summary” section, usage of the “to check” section is more uniform. As depicted in figure X, the “to check” section typically includes clinical tasks, referred to as “action items” in this analysis, to be performed by a provider listed on separate lines. Action items occasionally include additional information specifying conditions (e.g. “if <2 cc/kg/hr in 8 hour period, please bolus with 10cc/kg NS”) and times (e.g. “q6h” or “at 3pm”). Designating a task to “follow-up” was a common practice, the results of which are summarized in Table 11.

Table 10: Case summary formats

Terse, code-like	BD: 8/30 0314, SVD, 38-2 wga, G3P2now3 26 y/o Mom; mat labs neg; Apgars 7,9 BW: 7lb 1oz; bottle B+
Brief narrative	56 year old male with CAD, HTN, DM, hyperlipidemia who presented 11/14 with STEMI. Cath with stent to RCA then 3d later cath with stent to RCA, LAD. Now w CAP on IV ABX. Weaning off O2.
Lengthy narrative	Mr. Smith is a 75 year old male with a PMH significant for severe Crohn's disease treated with immunosuppressants Remicaide and mercaptopurine, s/p multiple abdominal surgeries with short gut syndrome, s/p right upper extremity DVT on Coumadin who presented to the Vanderbilt ED this morning complaining of shortness of breath, chest tightness/discomfort, and left shoulder pain at the site where a Hickman catheter was placed on 11/12/06 for TPN. In MICU s/p extubation 12/6, now on 3L NC with good saturations.
Organ system-based list	3yo F S/p laryngotracheoplasty with cartilage graft dehiscence and MRSA infection of graft 1. CV: HDS 2. Resp: s/p brochoscopy with laser of anterior cartilage graft dehiscence - initially intubated and currently weaned to room air sating 97-100%; continues to have UAN but no stridor - Decadron currently 1.5mg IV Q8H (from 3.0mg Q8hours this am)--will continue to wean 3. FEN/GI: currently tolerating regular diet with no need for IVF 4. ID: MRSA on culture of graft dehiscence, currently D#3 of Vancomycin and will start Rifampin for synergy - will need to discuss with team/ID length of treatment 5. Neuro: currently Methadone 0.15mg po Q12hours for 2 days, d/c\'ed 9/29 6. Access: patient had PICC placed on 9/28, CXR shows good placement

Table 11: Follow-up details

Laboratory result	53	38.13%
Consult recommendation	39	28.06%
Imaging result	19	13.67%
Appointment	14	10.07%
Other	14	10.07%
Total	139	

The researcher observed 139 follow-up entries in 96 patient cases, or 13.1% of total patient cases. Examples of follow-up statements include the text “followup” or abbreviation “f/u” followed by “…K+ this evening” (laboratory), “…neuro recs” (consult recommendation), “…head CT” (imaging result), “…see Dr. Jones again in three weeks” (appointment), and “…pain control” (other). Although users mostly listed actions to perform in the “to check” section, occasionally they included items that required awareness rather than action. In the final 150 patient cases reviewed (20.5% total cases), the researcher observed 20 awareness items (13.33% of cases reviewed, 2.7% of total cases). Table 12 provides a list of awareness items.

Table 12: Awareness item details

Past event	10	50%
Future event	3	15%
External event	3	15%
Incoming phone call	2	10%
Wait on process	2	10%
Total	20	

Awareness items included statements like “was cultured today” (past event), “patient to undergo appendectomy tomorrow” (future event), “ENT draining abscess this afternoon” (external event), “may get call from endo” (incoming phone call), and “awaiting recs” (wait on process). Awareness items were usually accompanied by an indication that there was “nothing to do” for a patient.

Although “case summary” and “to check” sections generally served distinct purposes, users had a tendency to place the same information in different places. Discharge information, name and phone number of a covering or attending physician, code status, and orders to execute appeared frequently in either the “case summary” and “to check” sections. The researcher also noted clinical action items typical of the “to check” section being listed in the “case summary” section on some patients.

Abbreviations were prevalent across all sign-out notes. “NTD,” the abbreviation of “nothing to do,” was the most common expression in the entire data set. Almost every case included an "NTD" at some point. Typical of notes mentioning discharge was the abbreviation "OTD," meaning "out the door." "Followup" was commonly abbreviated "f/u," and both "discharge" and "discontinue" as "d/c." Laboratory tests like basic metabolic profile ("BMP") and imaging studies like chest x-ray ("CXR") were also commonly abbreviated. Notes for surgery patients often included instructions about the acute pain service ("APS"). In addition to abbreviations, users commonly used numbered or bulleted lists to arrange items in "to check" sections, and placed brackets ("[]") before particular action items as if to provide a "check box" on a print out.

"Case summary" and "to check" sections occasionally included personal commentary from users about patients, patients' family members, and other providers. Examples include "65 year-old woman is very pleasant to talk to," "32 year old Spanish-speaking man presents with...," "patient's mother is not very understanding," and "[patient has] an aspiration pna now from too much ativan from cross-cover--don't be that guy."

"Case summary" length and format

"Case summary" length emerged as a salient phenomenon, and the researcher classified the lengths of "case summary" sections as short (one to five lines), medium (six to ten lines), or long (eleven or more lines). Based on the prevailing "case summary" length category of each unit, the researcher then classified units/services as short, medium, long, or all (a combination of short, medium, and long). Units were then grouped by care similarity. Table 13 presents units classified by "case summary" length. Short "case summary" sections were the most commonly occurring (20 units), followed by long (8 units), all (6 units), and medium (4 units). A variety of care specialties produced short sections, while pediatric units exclusively created medium and long sections. Women's surgery also created long sections. The "all" length category consisted of an equal number of pediatric and adult units. To see if units in each length classification's care similarity groups contained any content or formatting similarities, the researcher compared units on the basis of categories discovered through open coding.

Table 13: Unit "Case Summary" Length Classifications

Short	Medium	Long	All
Surgery Surgical ICU Surgical stepdown Main operating room Neurosurgery Orthopaedics Trauma ICU *Intensive care* Surgical ICU Cardiac ICU Medical ICU Trauma ICU *Cardiology* Cardiac cath lab Cardiac ICU *Adult medicine* Adult medicine Adult neurology Adult myelosuppression Adult medicine round wing Subacute Renal Dialysis *Obstetrics* Normal nursery Labor and delivery *Adult Emergency* Adult ED Adult observation	*Pediatric* Pediatric critical care Neonatal ICU Pediatric young surgery Stallman neonatal ICU	*Pediatric medicine* Pediatric medicine Pediatric cardiology Pediatric neurology Pediatric adolescent medicine *Pediatric oncology* Pediatric myelosuppresion Pediatric hematology/oncology *Pediatric surgery* Pediatric adolescent surgery *Adult surgery* Women's surgery	*Pediatric* Pediatric ED Pediatric observation Pediatric surgery *Adult* Adult general surgery Cardiology Post partum

Short “case summary” sections

The researcher identified six care similarity groups for units classified as having short “cases summary” sections: surgery, intensive care, cardiology, adult medicine, and obstetrics.

In all surgery units there was at least one note containing the abbreviation “APS:“ followed by care instructions. “Case summary” entries generally consisted of a one-to-two line statement. Action items appeared in the “to check” section infrequently. Resident physicians generated almost all notes. Content and format in notes generated by the trauma unit was largely different, and the differences are explored later in this analysis. The distinctive note style of the trauma unit appeared in at least two cases in the surgical stepdown and neurosurgery units, showing the transfer of patients between trauma and those units.

Common features between the intensive care units were frequent use of action items in the “to check” section (47.5%). “Case summary” entries generally consisted of a one-to-two line statement. Resident physicians generated almost all notes.

Both the cardiac catheterization lab (CCL) and cardiovascular intensive care unit listed “NTD” in the “to check” section in upwards of 40% of notes. “Case summary” notes were also one-to-two lines in length. Nurse practitioners generated most notes for CCL patients, and the majority of those notes appeared to be for patients admitted overnight after a catheterization. Resident physicians generated most notes for the CVICU. Use of the sign-out tool by CVICU providers is noteworthy considering that the CVICU has a separate sign-out tool based on Quill, a structured data capture tool developed internally.

Adult medicine notes commonly featured brief narratives and a consistent use of action items, conditional action items, and discharge planning information. Nearly all notes produced by the dialysis unit listed "NTD" in the "to check" section, a pattern which no other units exhibited. Code status was mentioned in notes in all but two units.

Obstetrics notes had a decidedly maternal focus, featuring separate sections labeled for mother and baby. Many label-value pairs and dates of delivery appeared in the "case summary" sections. Labor and delivery notes featured a terse, code-like style to "case summary" sections. Discharge information was commonly listed in either the "case summary" or "to check" section for both units (55% in normal nursery, 29% in labor and delivery).

Medium "case summary" sections

Three pediatric units comprised the medium group—neonatal intensive care (NICU), pediatric critical care (PCCU), and young surgery. In the NICU and PCCU, 95% of the "case summary" sections in both units were organ system-based. Young surgery featured 50% of "case summary" sections arranged by system. The NICU and PCCU extensively entered action items in the "to check" section whereas young surgery did not. The NICU and PCCU action items were also commonly marked by the use of conditional statements. Evidence of copying and pasting contents from the electronic medical record were mostly lacking, suggesting that users create original notes. Young surgery included discharge information in 60% of its cases.

Long "case summary" sections

Pediatric medicine, pediatric surgery, pediatric oncology, and women's surgery were identified as care similarity groups in the long "case summary" classification.

Pediatric medicine "case summary" sections are arranged using an organ system-based technique 83% of the time. A minimum of 60% of notes are copied and pasted from the electronic medical record with the same note ("Progress Note Daily Progress Note") being the target for copy/paste in neurology and medicine 60% of the time. Pediatric medicine "to check" sections feature action items and the name and pager number of a provider frequently. 50% of cases contain discharge information.

Adolescent surgery features action items in the "to check" section of cases 80% of the time. Conditional statements make up about half of the action items. Snapshot orders are mentioned 40% of the time. 50% of "case summary" sections are system-based, and 60% of "case summary" sections are copied and pasted from the electronic medical record.

Pediatric oncology features system-based formatting and copying and pasting from the electronic medical record in a minimum of 80% of cases. The majority of copy-paste operations involve progress notes. "To check" section action items are listed frequently in both units.

Women's surgery "case summary" sections features a system-based approach in 33% of cases and copy-and-paste from the electronic medical record in 16% of cases. "Case summary" sections are broken down in sections in 50% of cases. 75% of cases feature action items in the "to check" section. Discharge information is not commonly listed.

All “case summary” sections

Two groups comprised the all section—adult, consisting of adult general surgery, post partum, and cardiology, and pediatric, consisting of pediatric surgery, pediatric emergency, and pediatric observation. Among adult units, 50% of cases in post partum and cardiology featured resident physicians generating the first “case summary” in a case. Adult general surgery did not share considerable similarity with post partum and cardiology. Among pediatric notes, most notes in all units featured a system-based format.

Care similarity

Choosing to group units/services by “case summary” length was a first step in deconstructing the varied use of sign-out notes. Identifying units’ care similarities in each of the “case summary” length classifications focused analysis on presumed commonality of data elements. Patients presumably would be transferred between units providing complementary or similar care and not to units solely based on similar “case summary” section length. Accordingly, the researcher compared units/services in terms of similarity of care and sign-out note content, independent of “case summary” length. The arrangement is presented in Table 14.

Table 14: Units/services according to similarity of care and sign-out note content

Adult cardiology Cardiac catheterization lab Cardiac ICU Cardiology	*Adult medicine* Adult medicine Adult medicine round wing Subacute Neurology Renal Adult myelosuppression Medical ICU Dialysis	*Adult surgery* Women's surgery Surgical ICU Surgical stepdown Adult operating room Neurosurgery Trauma Adult general surgery Orthopaedics
Adult emergency Adult ED Adult observation	*Trauma* Trauma	*Childbirth* Labor and delivery Post partum Normal nursery Stallman nursery Neonatal ICU
Pediatric surgery Adolescent surgery Young surgery Pediatric surgery	*Pediatric medicine* Adolescent medicine Pediatric neurology Pediatric cardiology Pediatric hematology/oncology Pediatric myelosuppression Pediatric CCU	*Pediatric emergency* Pediatric ED Pediatric observation

Adult cardiology

Cardiology, cardiac catheterization lab, and the cardiovascular intensive care unit comprise adult cardiology. "Case summary" sections are short with the exception of Cardiology floor units being more varied. Sign-out notes commonly exhibit the transfer of patients into cardiology: 25% of cardiology cases start in the CCL, and 5% start in the CVICU. In cardiology, MD's started 52% of sign-out notes, nurse practitioners 43%, registered nurses 3%, and case managers 2%. In the CCL, NP's started 76% of notes and MD's 24%. MD's started notes exclusively in the CVICU. The participation of nurse practitioners in all but the CVICU is notable. Nurse practitioners generated most notes for CCL patients, and the majority of those notes appeared to be for patients admitted overnight after a catheterization. Discharge information was prevalent in cases from the

CCL and in cardiology, but not in CVICU. Users listed a name and phone number of a physician in 43% of cardiology cases and 66% of CCL notes. Action items in the “to check” section appeared in about 30% of cases on average.

Adult medicine

Adult medicine, adult medicine round wing, subacute, neurology, renal, adult myelosuppression, medical intensive care, and dialysis comprise adult medicine. The majority of notes are short. Code status was indicated in all but three low sign-out volume units (subacute, renal, dialysis). Users provide action items in the “to check” section in more than 20% of cases in all units. In myelosuppression, action item use is upward of 58%. Discharge information is mentioned somewhat frequently. Compared to other units, dialysis was an outlier because “to check” sections almost always included “NTD.”

Adult surgery

Women’s surgery, surgical intensive care, surgical stepdown, VHR Main OR, neurosurgery, trauma, adult surgery general, and orthopaedics comprise adult surgery. With the exception of lengthy notes in women’s surgery, most surgery notes are short. Action items are included in “to check” sections in 30% to 75% of cases seen in each unit. Trauma notes differed greatly from all adult surgery notes. Discussion of trauma is to follow.

Adult emergency

Adult emergency department and adult observation comprise adult emergency. In both units notes are typically short and feature frequent "NTD" entries in the "to check" section. Patients with notes generated in the adult emergency department are usually admitted to adult general medicine and cardiology units, and sign-out notes continue to be edited following patient transfer.

Trauma

Trauma is a noted outlier among units/services using the sign-out tool. Case managers and registered nurses start sign-out notes for more than 90% of cases. Notes usually contain information used for disposition in the same format: "DC plan," "Residence," and "Insurance" on three separate successive lines. 96% of "to check" sections are blank in trauma. The distinctive note style is observed in other surgical units where trauma patients are often transferred, including surgical stepdown, neurosurgery, and adult general surgery. Of the 10% of notes not started by case managers or nurses, resident physicians are responsible. These notes are usually lengthy and contain information copied and pasted from an unidentified electronic source.

Childbirth

Labor and delivery, normal nursery, post partum, Stallman nursery, and neonatal intensive care comprise childbirth. Terse, code-like statements make up a good number of the notes produced in labor and delivery, normal nursery, and post partum units. Notes for these units generally include separate sections for mother and baby along with childspecific information like APGARS scores, circumcision plans, and labs. "To check" items for newborns often include scheduling appointments for followup visits with primary care physicians. Discharge information is present in more than 50% of cases in normal nursery and post partum. Pregnancy-specific information is also included for mothers, like "to check" items concerning discussions about contraception and expectant management. Post-partum day numbers are also often listed for mothers. Action items in "to check" sections are present in 69% of post partum cases, 62% of NICU cases, 38% of labor and delivery cases, and 14% of normal nursery cases.

Unlike the other units, the Stallman nursery and NICU feature longer and system-based notes. Stallman nursery notes contain the names of organ systems but not content. All notes created in Stallman are later edited in the NICU. This is most likely a result of the Stallman nursery serving as a neonatal intensive care unit immediately adjacent to the labor and delivery area while the main NICU is located in the separate Children's Hospital. It would appear that Stallman nursery creates templates for the NICU to use. NICU notes are medium in length and appear synthesized rather than copied-and-pasted from the electronic medical record.

Pediatric surgery

Young surgery, adolescent surgery, and pediatric surgery comprise pediatric surgery and include a variety of "case summary" note lengths. More than 50% of cases contain system-based "case summary" sections. Action items are present in the "to check" section for more than 75% of cases in adolescent and pediatric surgery, while young surgery is 30%. Discharge information is present in the “to check” section of notes in at least 50% of cases, with the exception of only 16% in pediatric surgery.

Pediatric medicine

Pediatric medicine includes adolescent medicine, pediatric neurology, pediatric cardiology, pediatric hematology/oncology, and pediatric myelosuppression. “Case summary” sections produced by pediatric medicine were almost always long, with the exception of pediatric critical care being medium. Nearly 100% of “case summary” sections were system-based, and upwards of 66% were copied and pasted from the electronic medical record. Units included action items in the “to check” section of notes in more than 50% of cases. Conditional statements were common in upwards of 33% of notes with the exception of 22% in pediatric medicine. Users listed discharge information in the “to check” section in nearly 50% of cases. Pediatric medicine and adolescent medicine notes featured the name and pager number of a physician in 42% and 50% of cases, respectively. 33% of pediatric critical care cases were transferred to pediatric medicine units.

Pediatric emergency

Pediatric emergency includes the pediatric emergency department and pediatric observation. Notes were generally medium to long, and 80% included information copied and pasted from the electronic medical record. Discharge information was present in 40% of cases.

Discussion

The emergence of "case summary" length classifications and care similarity groups show differences in sign-out note content across hospital units/services, leading the researcher to reject Hypothesis 3_0. Although "case summary" length classifications differentiate units/services, meaningful distinction between units/services is apparent when examining the use of sign-out note content according to care similarity. A variety of content formats and unanticipated use of the sign-out tool by non-providers shows how software intended for one purpose can be adopted for a multitude of purposes. The results ask administrators and informaticians, "Do you know how your legacy system is used?" Discovery of multidisciplinary use can influence the design of new software.

Socialization

Care similarity groups and the individual differences within them are evidence of discipline-specific sign-out note content and format practices. For example, the patient care processes, patient care goals, and sign-out information needs of adult cardiology and OB/GYN differ; similarly, the processes, goals, and needs of the cardiac catheterization lab and cardiology floor units differ.

Providers' sign-out note writing strategies reflect the documentation norms of each unit/service as well as the broader process of socialization that providers experience in their discipline-specific training and practice. All pediatric units/services, regardless of medical or surgical specialty, used an organ-system based approach in their sign-out notes. However, pediatric medicine units use the sign-out tool in a minimum of 75% of patient cases, whereas pediatric surgery units use the tool in a maximum of 45% of cases.

In adult units/services, medicine's brief-to-longer narratives and relatively high sign-out cases to order cases ratio contrasted with surgery's one-to-two line notes and low sign-out cases to order cases ratio. Differences in socialization of pediatrics and adult physicians as well as between medicine and surgery are manifest in sign-out tool usage and note content.

Influence of first author

For most patient cases, the content and format of "case summary" sections remained relatively similar from the first authoring onward. Changes to "case summary" sections usually reflected updates in the status of patient conditions and procedures. These changes were usually appended to the end of existing content. Occasionally changes were incorporated within existing text, which was at times difficult for the researcher to detect during content analysis. The format of notes was relatively consistent starting from the first note generated. For example, if the first "case summary" entry for a patient case was a brief narrative, generally all following notes were brief narratives. Also, if an uncharacteristic "case summary" style was used in a unit (e.g. system-based instead of narrative), usually all following notes maintained the uncharacteristic style. The first author is seemingly the determinant of sign-out note content and format for other users. Consistency of "case summary" content and format from the first note shows user preference for standardization or indifference.

Blank notes

Although not measured explicitly in the content analysis, the researcher noted that users often printed blank notes consisting of null "case summary" and "to check" sections. Users might find utility in printing blank notes because of the patient demographics and open paper space for note taking. The hypothetical use of the printout for the listing of demographics only might suggest that some non-providers users ignore actual note content in favor of only using patient demographics to facilitate their tasks. Blank note printing might explain the high printing and low unique note generation levels in intensive care units, as discussed in Part A. Further research is required to understand the use of printed sign-out information by multiple professional roles.

Data capture: "case summary" section templates

Widespread and varied use of the sign-out tool shows that the software is flexible and fits workflow patterns. Consistent sign-out note content and formatting in care similarity groups and individual units/services suggests that users have adopted standardized documentation methods for the sign-out process. For some units/services the tool could be customized to reflect what is already being standardized to further reduce variability of sign-out content, a priority of the standardized handoff literature [10] and a national patient safety goal [20]. Standardized sign-out content ensures clinicians transfer the correct information and instructs those unfamiliar with the process of the information to communicate [10]. An example of discipline-specific sign-out note customization is the use of standardized templates for data capture in individual units/services. Because the free text nature of the existing sign-out tool provides users with flexibility of expression, a free text-based template may serve sign-out better than structured data entry. Data elements commonly retrieved from the electronic medical record through copy-and-paste could be automated using a "getter" function. Furthermore, natural language processing techniques like Denny et al's "Section Tagger" (2007) could be used to retrieve specific parts of clinical documents for use at sign-out. Although a free text-based template might benefit users in care similarity groups like childbirth, cardiology, and pediatric medicine, the existing sign-out tool might suffice for units with comparably unsophisticated sign-out note uses like adult surgery. However, templates for general surgery might also have the effect of increasing sign-out tool usage and thus standardization of content.

Data capture: code status and attending physician name and pager number

Certain clinical data elements used at sign-out might benefit from improved data capture. Although the sign-out tool displays information from active orders including patient's code status and attending physician's name and pager number, users frequently enter this information in both the "case summary" and "to check" sections of sign-out notes. This suggests that these data elements are not up-to-date in active orders and/or not displayed properly by the software. Reports from users indicate that code status orders are not entered often in the institution's CPOE system. An effort to improve provider identification is already underway as an operations project in the institution. An existing effort to improve provider identification in the hospital suggests that the capture of attending physician information has been identified as a problem. User input of code status and attending physician information shows the importance of these data items at sign-out. Improved capture and display of these elements can contribute to the standardization of sign-out content. Perhaps sign-out software can be used to capture code status and provider information. Options include structured data capture and exit checks.

Data capture: structured "to check" items

Results showed a tendency for users to list clinical task "action items" on separate lines in the "to check" section. The content of each task line was usually specific to a clinical activity to perform. Furthermore, some action items included conditional statements and timing information that provided more detail on things to do. Use of brackets to form a checkbox ("[]") show that users wish to record the status of change of completed tasks on paper. Taken together these observations suggest that the "to check" section consists of discrete items. Structured data capture can record discrete items so that the information can be more easily by the sign-out tool and other clinical information systems. Users might be able to more easily create and delete items from the "to check" section using a structured interface. Other systems like CPOE might add items to the "to check" section via a web service. For example, after a provider orders a laboratory test for a patient, a popup in the CPOE system might ask the user, "Would you like to add this item to your sign-out 'to check' list?" Such an intervention could potentially reduce the effect of provider forgetfulness (if it exists) in adding information to the sign-out sheet. However, factors like alert fatigue should be considered in such an intervention. Nonetheless, sign-out software and other systems can potentially use discrete "to check" items to improve information management and care.

Data capture: discharge information

Discharge information appears frequently in both "case summary" and "to check" notes. Because of potential overlap of content, one opportunity for system integration is with discharge planning software. Another opportunity involves capturing discharge information in a designated field at sign-out in order to provide administrators with information regarding bed management. For example, instead of a user listing "patient to be discharged in the morning," a user could click a checkbox corresponding to assumed morning discharge, which would feed an administrator's computerized dashboard with an indication of bed availability.

Data capture: order information

Indication of specific orders and "snapshot" orders to execute occurs somewhat frequently (a "snapshot" order is a list of orders specified by a user for later execution). Adding "snapshot" orders to the "current information" section or adding "snapshot" order information to sign-out from a CPOE intervention might increase timeliness of order execution. Further study is necessary.

Clinical outcome measures

Identification of clinical outcome measures related to the sign-out process and use of sign-out software requires further research. The data capture concepts presented in this section might provide the first steps to determining relevant measures for the sign-out process and sign-out software. That the literature contains only one study relating sign-out software usage and patient care outcome measures [31] suggests that patient-oriented sign-out clinical outcomes are difficult to identify and measures.

Limitations

Limitations of the sign-out content analysis include the use of a single reviewer to assess notes. As a result, the results do not have inter-rater reliability. The reviewer also lacks formal medical training, which might affect the concepts and themes identified.

CHAPTER V

DESIGN SPECIFICATION FOR SIGN-OUT SOFTWARE FUNCTIONALITY

Standardized sign-out content helps to ensure that the correct information is transmitted at sign-out and that individuals unfamiliar with a sign-out process can adapt appropriately [10]. Although sign-out content should be standardized for individual units/services in a hospital [10], there exists a fundamental body of information for every sign-out independent of medical specialty. According to a review of published sign-out data elements[30-34, 36], summarized in Table 15, and the preceding chapters of analysis, sign-out notes consist of four parts: demographic information, current information, a "case summary" section, and a "to check" section. Sign-out software obtains demographic information and current information from an up-to-date clinical data repository, if such a system is available. These data, shown in detail in Table 16, provide a basic understanding of any patient case. Users maintain text-based "case summary" and "to check" section content. In the "case summary" users express key points of a patient case, and in the "to check" users identify tasks to complete. Templates for "case summary" and structured data capture for "to check" sections, described in detail below, can be used as long as there ultimately remains a basic free text data entry option.

Table 15. Sign-out data elements and their sources per publication

	VUMC status quo	Van Eaton [34]	Frank [30]	Kushniruk [31, 36]	Petersen [31]	Sidlow [33]	Quan [32]
Demographics							
Name	C	C	C	C	C	C	C
Age	C	C	C	C	C	C	C
Date of birth	C	C	C				
Sex	C	C	C	C	C	C	C
Medical record number	C	C	C	C	C	C	C
Admission date	C	C	C	C	C		
Location							
Unit	C	C	C	C	C	C	
Bed	C	C	C	C	C	C	
Provider information							
Attending physician	C	C	C	C/M			
Team/service	C	M	C	C	C	C	
Pager numbers of residents	C		C				
Phone numbers of hospital services			C				
Call schedule				C			
Current hospitalization							
Admission diagnosis	C	M	C			M	
Medication allergies	C	C	C		C	C	
Food/other allergies	C		C		C	C	
Antibiotic list	C	M					
Medication list	C	M	C	M		C	
Diet		M	C				
Weight	C		C				
Tubes/lines/drains		M					
Code status	C	M			M		
Culture results		M	M		U		
Study results		M	M		U		
Consulting services			M				
User-generated content							
Sign-out information/patient plan/to do list	M	M	H	M	M	M	M
General status	M				M		
Active issues						M	M
Medical history			M	M			M
Problem list		M			U		
Procedure list		M					
C = Clinical information system ▪ M = Manual ▪ H = Handwritten ▪ U = Unknown							

Table 16. Data elements providing basic understanding at sign-out

Demographics	Current information
Name	Attending name
Bed	Attending pager number
Age	Team name
Gender	Team pager number
Medical record number	Diagnosis
Admission date	Allergies
	Weight
	Antibiotics
	Medications
	Code status
	Orders to execute

"Case summary" section

Through the use of template-based "case summary" sections, sign-out content can be standardized according to the needs of individual units/services. General and unit/service-specific templates should be available. The effect of the display of key information at sign-out is an area of future research.

Although sign-out information needs vary across units/services, not all units/services use sign-out software in sophisticated ways or as a standard part of their workflow. For these units, a general template suffices because it provides an outline for listing key points of a patient's case. The general template should be free-text based and, as per Frank's work [30], consist of headings for medical history, active issues, pertinent results, consulting services, pending labs and studies, and other issues of concern. For those units/services where individual templates are deemed necessary, developers should work with users and unit/service leadership to identify the data sections to include in templates. Templates can be specific to a unit/service and the types of care administered by a unit/service. For example, templates for pediatric medicine and adult cardiology units might include completely different sets of clinical information. Additionally, in an individual unit/service like obstetrics and gynecology there may be separate templates called "infant," "post partum mother," and "infant and post partum mother." To save users time and prevent potential copy-paste errors, templates can incorporate automatic retrieval of data from other electronic clinical documents. Future work will investigate whether the display of key information for providers at sign-out improves patient care.

"To check" section

The preceding analysis suggests that the "to check" section consists of discrete items that describe tasks for users to perform. Structured data capture can record discrete items so that the information can be more easily manipulated using sign-out software and other clinical information systems. Users might be able to more easily create and delete items from the "to check" section using a structured interface. Other systems like CPOE might be able to add items to the "to check" section via a web service. Although structured data capture of discrete "to check" items could be helpful, allowing users to enter free text information in the section enables users to flexibly express patient information and needs.

Additional structured data capture

Sign-out software can be used as a place in clinical workflow to capture information that is not otherwise well captured. Examples include code status and the names and pager numbers of attending and other physicians. Structured data capture beyond “to check” sections is optional and should be used judiciously in order to not pose a hindrance to clinical workflow. Another opportunity involves capturing discharge information in a designated field at sign-out in order to provide administrators with information regarding bed management.

Note versioning and history

The sign-out application should incorporate a versioning system so that users can track changes to “case summary” and “to check” sections and identify who is responsible for modifications. Identifying other authors provides users the opportunity to resolve questions pertaining to sign-out note content. If a note changes from the last time a user viewed it, the modified text is highlighted and the user responsible for the changes is indicated on screen. Users can access the sign-out note history for any patient case. History also includes the user responsible for each version.

Printing

Paper printouts generated by sign-out software are helpful for sign-out and ward work activities [34]. Sign-out printouts contain one to many sign-out notes ordered by patient’s last name or bed number. An option to print only patients’ demographic information and “to check” section should also be available. Users can print without saving changes. Printing is double-sided when possible to conserve paper. Developers should make thoughtful decisions concerning page layout, margin, spacing, and font selections.

System integration

Evidence of unintended multidisciplinary use of the sign-out tool at Vanderbilt University Medical Center suggests that non-providers derive utility from sign-out software, and that new software should seek to meet the varied needs of all users. However, it is unknown whether new software should be strictly designed for sign-out or multifaceted care team communication. Provider sign-out and nurse shift report are similar processes in terms of the transfer of patient care responsibility, and the information needs of the two processes might be similar and assisted by a common information system. A multidisciplinary patient management tool, perhaps in the form of an inpatient whiteboard [53], would incorporate a variety of clinical content including sign-out notes. Role-based views would determine the display of information for different users. Adapting information systems to the role-specific uses of sign-out note content can potentially lead to process improvements to benefit staff and patients. A whiteboard could display patient-specific clinical information aggregated from the electronic medical record and the “case summary” and “to check” sections created by sign-out software, as well as clinician on-call responsibility information. Discrete “to check” items created via an “add to sign-out” CPOE intervention (for orders like laboratory and imaging studies) would be accessible via the whiteboard by default. A whiteboard could enable attending physicians to more easily supervise the work of senior residents, and senior residents the work of junior residents, interns, and medical students [54]. The workflow and information needs of providers, nurses, and ancillaries could potentially become more transparent for all parties involved in certain situations. A multidisciplinary patient management tool could potentially assist institutions’ SBAR (situation-background-awareness-recommendation) initiatives as well. Protections will be needed to safeguard patient information according to HIPAA.

Mobile sign-out technologies

The release of the Apple iPhone in 2007 signals a shift in mobile technology that might influence clinical software like sign-out. Previous research has investigated the use of personal digital assistants (PDA) for managing sign-out data [37, 38], but no hardware at the time supported a full version of a web browser like the iPhone. Web-based sign-out software is platform independent and can be used rather easily on an iPhone (Figure 13). Additional study is required to determine the efficacy of the iPhone and similar mobile devices for sign-out.

Figure 13. iPhone provides access to web-based sign-out software

Identification of clinical outcome measures

Petersen's study of sign-out software reducing the risk of preventable adverse events during cross coverage [31] is the lone published patient-oriented outcome measure related to sign-out software use. Further study of the sign-out process can potentially reveal other outcome measures related to sign-out that could show the effect of the process and software on patient care. Results of future studies could affect how institutions view continuity of care and perform sign-out procedures.

BIBLIOGRAPHY

[1] Vidyarthi A. Fumbled Handoff. WebM&M 2004 [cited; Available from: http://www.webmm.ahrq.gov/case.aspx?caseID=55

[2] Kohn LT CJ, Donaldson MS, McKenzie D. To Err Is Human: Building a Safer Health System. Washington, DC: National Academy Press 2000.

[3] Coiera E. Communication systems in healthcare. The Clinical biochemist. 2006 May;27(2):89-98.

[4] Organizations JCotAoH. Sentinel Events Statistics. 2007 [cited May 18, 2007]; Available from: http://www.jointcommission.org/SentinelEvents/Statistics/

[5] Blumenthal D. Doctors in a wired world: can professionalism survive connectivity? The Milbank quarterly. 2002;80(3):525-46, iv.

[6] Perley CM. Physician use of the curbside consultation to address information needs: report on a collective case study. J Med Libr Assoc. 2006 Apr;94(2):137-44.

[7] Arora V, Johnson J, Lovinger D, Humphrey HJ, Meltzer DO. Communication failures in patient sign-out and suggestions for improvement: a critical incident analysis. Quality & safety in health care. 2005 Dec;14(6):401-7.

[8] Volpp KG, Grande D. Residents' suggestions for reducing errors in teaching hospitals. The New England journal of medicine. 2003 Feb 27;348(9):851-5.

[9] Gandhi TK. Fumbled handoffs: one dropped ball after another. Annals of internal medicine. 2005 Mar 1;142(5):352-8.

[10] Arora V, Johnson J. A model for building a standardized hand-off protocol. Joint Commission journal on quality and patient safety / Joint Commission Resources. 2006 Nov;32(11):646-55.

[11] Toussaint PJ, Coiera E. Supporting communication in health care. International journal of medical informatics. 2005 Oct;74(10):779-81.

[12] Jirjis J, Weiss JB, Giuse D, Rosenbloom ST. A framework for clinical communication supporting healthcare delivery. AMIA Annual Symposium proceedings / AMIA Symposium. 2005:375-9.

[13] Coiera E, Tombs V. Communication behaviours in a hospital setting: an observational study. BMJ (Clinical research ed. 1998 Feb 28;316(7132):673-6.

[14] Parker J, Coiera E. Improving clinical communication: a view from psychology. J Am Med Inform Assoc. 2000 Sep-Oct;7(5):453-61.

[15] Haggerty JL, Reid RJ, Freeman GK, Starfield BH, Adair CE, McKendry R. Continuity of care: a multidisciplinary review. BMJ (Clinical research ed. 2003 Nov 22;327(7425):1219-21.

[16] Anderson MA, Helms LB. Talking about patients: communication and continuity of care. The Journal of cardiovascular nursing. 2000 Apr;14(3):15-28.

[17] Fletcher KE, Saint S, Mangrulkar RS. Balancing continuity of care with residents' limited work hours: defining the implications. Acad Med. 2005 Jan;80(1):39-43.

[18] Petersen LA, Brennan TA, O'Neil AC, Cook EF, Lee TH. Does housestaff discontinuity of care increase the risk for preventable adverse events? Annals of internal medicine. 1994 Dec 1;121(11):866-72.

[19] Solet DJ, Norvell JM, Rutan GH, Frankel RM. Lost in translation: challenges and opportunities in physician-to-physician communication during patient handoffs. Acad Med. 2005 Dec;80(12):1094-9.

[20] Organizations JCoAoH. 2007 Hospital/Critical Access Hospital National Patient Safety Goals. 2007 [cited; Available from: http://www.jointcommission.org/PatientSafety/NationalPatientSafetyGoals/07_hap_cah_npsgs.htm

[21] Lee LH, Levine JA, Schultz HJ. Utility of a standardized sign-out card for new medical interns. J Gen Intern Med. 1996 Dec;11(12):753-5.

[22] Horwitz LI, Krumholz HM, Green ML, Huot SJ. Transfers of patient care between house staff on internal medicine wards: a national survey. Archives of internal medicine. 2006 Jun 12;166(11):1173-7.

[23] Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. Acad Med. 2004 Feb;79(2):186-94.

[24] Chassin MR, Becher EC. The wrong patient. Annals of internal medicine. 2002 Jun 4;136(11):826-33.

[25] Wilson RM, Runciman WB, Gibberd RW, Harrison BT, Newby L, Hamilton JD. The Quality in Australian Health Care Study. The Medical journal of Australia. 1995 Nov 6;163(9):458-71.

[26] Lingard L, Espin S, Whyte S, Regehr G, Baker GR, Reznick R, et al. Communication failures in the operating room: an observational classification of recurrent types and effects. Quality & safety in health care. 2004 Oct;13(5):330-4.

[27] Organizations JCotAoH. 2007 Hospital/Critical Access Hospital National Patient Safety Goals. 2007.

[28] Patterson ES, Roth EM, Woods DD, Chow R, Gomes JO. Handoff strategies in settings with high consequences for failure: lessons for health care operations. Int J Qual Health Care. 2004 Apr;16(2):125-32.

[29] Leonard M, Graham S, Bonacum D. The human factor: the critical importance of effective teamwork and communication in providing safe care. Quality & safety in health care. 2004 Oct;13 Suppl 1:i85-90.

[30] Frank G, Lawless ST, Steinberg TH. Improving physician communication through an automated, integrated sign-out system. J Healthc Inf Manag. 2005 Fall;19(4):68-74.

[31] Petersen LA, Orav EJ, Teich JM, O'Neil AC, Brennan TA. Using a computerized sign-out program to improve continuity of inpatient care and prevent adverse events. The Joint Commission journal on quality improvement. 1998 Feb;24(2):77-87.

[32] Quan S. Signing on to sign-out: creation of a web-based patient sign-out application. Healthcare quarterly (Toronto, Ont. 2005;8(4):100-2.

[33] Sidlow R, Katz-Sidlow RJ. Using a computerized sign-out system to improve physician-nurse communication. Joint Commission journal on quality and patient safety / Joint Commission Resources. 2006 Jan;32(1):32-6.

[34] Van Eaton EG, Horvath KD, Lober WB, Pellegrini CA. Organizing the transfer of patient care information: the development of a computerized resident sign-out system. Surgery. 2004 Jul;136(1):5-13.

[35] Van Eaton EG, Horvath KD, Lober WB, Rossini AJ, Pellegrini CA. A randomized, controlled trial evaluating the impact of a computerized rounding and sign-out system on continuity of care and resident work hours. Journal of the American College of Surgeons. 2005 Apr;200(4):538-45.

[36] Kushniruk A, Karson T, Moore C, Kannry J. From prototype to production system: lessons learned from the evolution of the SignOut System at Mount Sinai Medical Center. AMIA Annual Symposium proceedings / AMIA Symposium. 2003:381-5.

[37] Lei J SP, Chen ES, McKnight LK, Mendonca EA, Cimino JJ. Structured data entry of cross-coverage notes using a PDA. *Medinfo* 2004.

[38] Luo J, Hales R, Hilty D, Brennan C. Clinical computing: electronic sign-out using a personal digital assistant. Psychiatric services (Washington, DC. 2001 Feb;52(2):173-4.

[39] Bates DW, Gawande AA. Improving safety with information technology. The New England journal of medicine. 2003 Jun 19;348(25):2526-34.

[40] Vanderbilt Medical Center, By the Numbers. [cited; Available from: http://www.mc.vanderbilt.edu/root/bythenumbers.html

[41] Robinson P. Best of Breed (BOB) v Fully Integrated Software (FIS). 2003 [cited 2007 June 5]; Available from: http://www.bpic.co.uk/articles/bobvfis.htm

[42] Giuse DA. Supporting communication in an integrated patient record system. AMIA Annual Symposium proceedings / AMIA Symposium. 2003:1065.

[43] Geissbuhler A, Miller RA. A new approach to the implementation of direct care-provider order entry. Proc AMIA Annu Fall Symp. 1996:689-93.

[44] Miller RA, Waitman LR, Chen S, Rosenbloom ST. The anatomy of decision support during inpatient care provider order entry (CPOE): empirical observations from a decade of CPOE experience at Vanderbilt. Journal of biomedical informatics. 2005 Dec;38(6):469-85.

[45] Giuse DA. Provider order entry with integrated decision support: from academia to industry. Methods of information in medicine. 2003;42(1):45-50.

[46] STARPANEL Vanderbilt's Electronic Medical Record.

[47] Miller R. History of WizOrder. In: Campion T, ed. Nashville: Personal communication 2007.

[48] Rosenbloom ST, Grande J, Geissbuhler A, Miller RA. Experience in implementing inpatient clinical note capture via a provider order entry system. J Am Med Inform Assoc. 2004 Jul-Aug;11(4):310-5.

[49] Ash JS, Sittig DF, Poon EG, Guappone K, Campbell E, Dykstra RH. The Extent and Importance of Unintended Consequences Related to Computerized Provider Order Entry. J Am Med Inform Assoc. 2007 Apr 25.

[50] Hawthorne Effect. 2007 [cited 2007 July 3]; Available from: http://en.wikipedia.org/wiki/Hawthorne_effect

[51] SPSS 13.0 for Windows. 13.0.1 ed. Chicago: SPSS Inc. 2004.

[52] Strauss AL, Corbin JM. Basics of qualitative research : grounded theory procedures and techniques. Newbury Park, Calif.: Sage Publications 1990.

[53] France DJ, Levin S, Hemphill R, Chen K, Rickard D, Makowski R, et al. Emergency physicians' behaviors and workload in the presence of an electronic whiteboard. International journal of medical informatics. 2005 Oct;74(10):827-37.

[54] Morgan MB, Branstetter BFt, Mates J, Chang PJ. Flying blind: using a digital dashboard to navigate a complex PACS environment. J Digit Imaging. 2006 Mar;19(1):69-75.