PATTERNS OF ACTION ITEMS IN AN ELECTRONIC CLINICAL HANDOVER TOOL

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Abstract

Background: Clinical handover is a complex process in which information and professional responsibility are transferred from one clinician to another. Communication gaps during clinical handover can contribute to medical errors, but structured clinical handover tools have been shown to reduce medical errors.

Objectives: 1) Classify free-text action items from an electronic clinical handover tool into categories using an existing standard; 2) Understand patterns of action items in an electronic handover tool; and 3) Examine the relationship between categories of action items and patients' acuity level.

Method: This was a descriptive study in which one year of data from an electronic clinical handover tool were examined (July 1, 2015 to June 30, 2016). Free-text data were classified using continuity of care document categories from Health Level 7, and additional categories were created as needed. A chi-squared analysis was used to examine the relationship between number of action items per category and patients' acuity levels.

Results: Action items (n=3,444) were entered for 783 patients by 168 physicians. Most action items aligned with the continuity of care document categories (n=2949, 85.6%) and two additional categories were created, *consults (n=431, 12.5%)* and *other (n=64, 1.9%)*. The most and least frequently documented categories were 'results', 'consults', and 'plan of treatment,' and 'advanced care plan,' 'education,' and 'social history' respectively. Most action items (n=3,039, 88%) had a documented acuity and were documented most frequently for patients with the stable acuity in the categories 'results', 'consults', and 'plan of treatment'. A significant difference was found (X^2=133.3, (*df*=36), *p*<0.001) with stable acuity (n=2381, 78.3%) being more likely to

have action items entered than discharge acuity (n=30, 1%), watch acuity (n=581, 19.1%), or unstable acuity (n=47, 1.5%).

Conclusion: Action items in the electronic clinical handover tool were found to align with the continuity of care document categories. Standardization within electronic clinical handover tools may reduce complexity by allowing for consistency in information documented during clinical handover, and interoperability between different electronic clinical handover tools. In the future, natural language processing could allow for automated classification of free-text action items.

Lay Summary

Clinical handover is performed millions of times a year by healthcare providers, and a variety of electronic clinical handover tools are used. Information that is missing or misunderstood during clinical handover can contribute to medical errors. This study examined 'action items' or 'to-do tasks' entered by physicians into an electronic clinical handover tool. The study aimed to examine 1) the categories of free-text action items documented in an electronic handover tool using an international standard for communication about patients; 2) the patterns of action items in the electronic handover tool; and 3) the relationship between action item category and patient acuity rating. The categories of action items documented aligned with categories in the international standard. Patients who are medically stable had more action items documented than medically unstable patients or patients ready for discharge. These findings highlight that the categories may be used as headings in free-text 'to do lists' for physicians which may provide organization and clarity around what action(s) need to be taken for the patient.

Preface

Ethics approval for this study was obtained from the University of British Columbia's Research Ethics Board and the Providence Health Care Institutional Approval, UBC BREB certificate number H16-01804. Permission to perform the study was received from the director of medicine at St. Paul's Hospital. I designed and performed the research in collaboration with my supervisor Dr. Leanne Currie. Committee members Dr. Suzanne Hetzel Campbell and Dr. Sabrina Wong provided guidance on the research design and data analysis.

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Chapter 1: Introduction

1.1 Background

Clinical handover, also known as shift report, signout, and handoff, occurs millions of times each year between healthcare practitioners worldwide (Abraham et al., 2015; Johnson, Jefferies & Nicholls, 2012). Clinical handover is a key component of continuity-of-care in which communication and cooperation between providers ensures consistent care is delivered to patients (Ujjen, Schers, Schellevis, & van den Bosch, 2012; Guthrie, Saultz, Freeman & Haggerty, 2008). Clinical handover occurs during care transitions, which are events where patients are transferred from one area in a hospital to another, or transferred to a different healthcare setting (Accreditation Canada, 2016). Perhaps most importantly, clinical handover involves both the exchange of information and the transfer of accountability of patient care (Alvarado et al., 2006), and both are crucial to ensuring continuity-of-care. For the purpose of this thesis, the term 'clinical handover' will be used and refers to physician-to-physician exchange of information and transfer of accountability during shift change (Alvarado et al., 2006). This study examined a Web-based physician-to-physician clinical handover tool, recognizing that aspects will be relevant to computer-based handover for nurses and other clinicians.

Recently, several researchers have explored the use of computer systems to support clinical handover (Starmer at al., 2014; Flemming and Hubner, 2013; Collins, Stein, Vawdrey, Stetson and Bakken, 2011). In addition, international standards organizations have begun to establish standardized content of computerized electronic health records (EHR), including handover tools. One of the EHR standards is a continuity of care document (CCD) architecture which provides standards for electronic documentation of patient summary information for the purpose of information exchange between health care providers (Health Level Seven International, 2016; Health Level Seven International, n.d.-b). This will be described in more detail in Section 1.5.3 and in Chapter 3. Although EHR standards exist for patient summary information exchange, they are not consistently used when clinical handover is performed (Starmer et al., 2012).

1.2 What is Clinical Handover?

According to communication theory, clinical handover is an example of when a message is sent from a sending agent (one physician) to a receiving agent (another physician) through a communication channel (e.g., via a verbal exchange, through digital tools, email, written correspondence, or a combination of verbal and written communication) (Coiera, 2015; Flemming & Hubner, 2013). Verbal clinical handover involves face-to-face conversation between clinicians, whereas, written clinical handover does not involve face-to-face communication, rather the information is written by the sending clinician and read by the receiving clinician (Flemming & Hubner, 2013). When clinical handover occurs via face-to-face communication, the process typically encompasses the following steps: presentation of patient information by the physician who is giving handover, an opportunity to discuss the meaning of the information, ask questions, and seek clarification by the physician receiving handover (Canadian Medical Protective Association, n.d.). The steps of handover may or may not include documentation of the information given by one physician and notes taken by the receiving physician (i.e., even if the message is delivered in writing, the written note is not necessarily saved or stored) (Canadian Medical Protective Association, n.d.). Accreditation Canada states that relevant patient information must be effectively communicated, using documentation tools and communication strategies in a standardized manner during care transitions, and that information shared during care transitions should be documented in the medical record (Accreditation Canada, 2016). Accreditation Canada (2013) also identifies effective care transitions as key to providing high-quality health care across a patient's care continuum. Effective handover occurs when care is coordinated despite separate patient care events occurring between care providers within the same care area, or across different care areas (Accreditation Canada, 2013). See Table 1.1 for key terms.

Table 1.1: Key Terms and Definitions

Term	Definition
Care Transition or Transitions of Care	""Transitions of care" refer to the movement of patients between health care practitioners, settings, and home as their condition and care needs change" (Joint Commission, 2012). Transitions of care include: handover to another practitioner, admission, transfer, and discharge points (Accreditation Canada, 2016).
Clinical Handover	Clinician-to-clinician exchange of information and transfer of accountability during shift change (Alvarado et al., 2006). Also known as: 'handover,' 'shift-to-shift report,' 'shift report,' 'change-of-shift report,' 'signout,' and 'handoff'.
Communication	An exchange of information from one clinician to another via a communication channel (Coiera, 2015).
Communication Channel	The method by which a message is transferred from one clinician to another (Coiera, 2015). For the purpose of this thesis the communication channel is the VirtualWard electronic clinical handover tool.
Continuity of Care Document (CCD)	Document that provides the content of a patient summary document allowing for information exchange between health care practitioners. The document has structured elements and free-text elements (HL7 International, n.d.-b).
Continuity-of-care	According to Guthrie et al. (2008) there are three types of continuity-of-care: - **Informational continuity:** information includes formal information required for best practice, standards reporting, etc. and also patient preferences and context. - **Management continuity:** Explicit designation of who will do what when enacting guidelines or protocols. - **Relationship continuity:** Inclusion of past care and expectations of future care built on accumulated knowledge of the patient and their circumstances.
Information	Clinical evidence formed from data and facts that have had context and meaning applied, which allows for a clinician's judgment to be informed about the course of action for a patient (Coiera, 2015).
Message	The information sent between healthcare providers (Coiera, 2015).

1.3 Communication Failures and Patient Safety

Despite recommendations for best practice for clinical handover, miscommunication between practitioners frequently results in missing or misunderstood information (Johnson, Jefferies & Nicholls, 2012) and communication gaps during clinical handover can contribute to errors in patient care. In 2007, the World Health Organization (WHO) identified provider handover communication as one of its "High 5 Patient Safety Initiatives" (2007)[1] to address communication gaps such as missing or incorrect information leading to incorrect treatments and disruptions to the continuity-of-care (World Health Organization [WHO], 2007; Abraham et al., 2015; Starmer et al., 2014; Johnson, Sanchez & Zheng, 2016). Communication breakdowns have been associated with diagnosis delays, incorrect treatments, mortality during weekend admissions, increased length of stay, increased laboratory tests done, and delays in care (Johnson, Sanchez & Zheng, 2016; Denson, McCarty, Fang, Uppal & Evans, 2015).

The Joint Commission in the United States estimates that gaps during clinical handover account for approximately 35% of unanticipated sentinel events (i.e., events which result in patient harm or death or severe temporary harm that requires an intervention to sustain the patient's life) (Abraham et al., 2015; US Joint Commission, 2016). The Australian Commission on Safety and Quality in Health Care has also attributed communication breakdown during handover to adverse patient outcomes (Johnson, Sanchez & Zheng, 2016).

In the Canadian context, the Canadian Patient Safety Institute (CPSI) has developed the Canadian Incident Analysis Framework (Canadian Patient Safety Institute, 2011). In this framework the term 'harmful incident' is used to describe "a patient safety incident that resulted

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[1] The other four patient safety initiatives were: medication reconciliation, performance of the correct procedure on the correct body part, management of concentrated injectable medications, and management and decreasing health-care related infections (WHO, 2007).

in harm to the patient" (Canadian Medical Association Journal, 2016). In a 2016 report from the Canadian Medical Association Journal, 5.6% of hospitalizations in Canada resulted in a harmful incident, with 1 in 8 of these resulting in death (i.e., 0.7% of all hospitalizations resulting in a preventable death in Canada). The CPSI has not provided information about the causes of these harmful incidents therefore it is unknown what proportion can be attributed to communication gaps during patient care transitions, but it is likely that some of these are related to communication gaps or miscommunications.

1.4 Effectiveness of Clinical Handover Practices

When examining the effectiveness of each method of clinical handover, verbal clinical handover has been shown to result in only 2.5% of information retention after five handovers (Johnson, Jeffries & Nicholls, 2012). While verbal and written handover together may result in less information loss, written clinical handover alone does not allow for interaction between individuals (Johnson et al., 2012; Li, Ali, Tang, Ghali & Stelfox, 2012). Written clinical handover in a paper-based modality can lead to information loss and increased use of physician time due to illegibility of handwriting, and lack of traceability of the author (Pryss, Mundbrod, Langer & Reichert, 2015; Starmer et al., 2013; Li et al., 2012).

1.4.1 Mnemonics to Support Clinical Handover

Mnemonics can support effective clinical handover by providing structure to remind clinicians of the information which must be communicated during handover (Starmer et al., 2012). Starmer and colleagues (2012) identified 24 different handover mnemonics used by various healthcare practitioners noting that many of these handover mnemonics have not been studied and their rationale for development was not thoroughly described. In response to this identified gap in evidence, the researchers created the I-PASS mnemonic which provides a method to exchange structured information about “**I**llness & severity”, “**P**atient summary”, “**A**ction list”, “**S**ituation awareness and contingency plans”, and “**S**ynthesis by the receiver” (Starmer et al., 2013). In a multi-site study, Starmer and colleagues examined both the implementation and effectiveness of the tool and an education component to teach best practices for handover and communication. In that study, the researchers found a 23% decrease in medical errors including: prevention of incorrect or delayed diagnosis, errors in the physical examination, medication errors, procedure errors, falls, and hospital-acquired infections.

Despite the success of the I-PASS study, Abraham et al. (2015) noted that the US Joint Commission was unable to standardize handover tools because no consistent structure or content of an electronic handover tool has been adopted, and multiple structured formats of electronic handover tools are in use (Abraham et al., 2015). National efforts in several countries (Quality Improvement Clinic, 2015; Canadian Patient Safety Institute, 2012; Australian Commission on Safety and Quality in Health Care, n.d.) are striving to provide tools for improving the handover process, but, to date, no international standards have been set for traditional or electronic clinical handover practices.

1.5 Electronic Handover Tools

Computerized systems, such as electronic health records and electronic clinical handover tools, can help clinicians accomplish tasks, and have become more frequently used in healthcare (Guilbeault, Momtahan, & Hudson, 2015). Electronic handover tools are electronically-based aids to support clinicians during handover (Flemming & Hubner, 2013). Electronic handover tools have the potential to improve handover by: 1) eliminating handwriting, which improves the timeliness and legibility of the handover, 2) providing electronic 'to do' lists, and 3) providing a structured approach to information transfer during handover (Starmer et al., 2013; Collins, Stein, Vawdrey, Stetson & Bakken, 2011). Electronic handover tools in conjunction with education about best practices for clinical handover have been shown to increase the quality and quantity of data in handover, and the accuracy of information transferred during handover (Flemming & Hubner, 2013). These tools have also been associated with decreased preventable adverse events such as wrong diagnoses, medication-related errors, procedure-related errors, and falls (Starmer et al., 2013; Li, Ali, Tang, Ghali & Stelfox, 2012).

1.5.1 General Features of Electronic Clinical Handover Tools for Physicians

Abraham et al. (2013, 2015) identified key informational components for physician-to-physician communication and recommend that key information components of electronic clinical handover tools include the following: 1) a patient identifier, summary of active issues, patient's current condition and status, important and critical events, assessment and plan, care plans, tasks and orders that need to be done in the near future, and possible complications (Abraham et al., 2015, Abraham et al., Meth, Bass & Hoke, 2013, WHO 2007); 2) the ability for the clinician to enter further rationale, directives, or explanatory information (Meth et al., 2013); and 3) the ability for documentation to be flagged so the receiving user can easily identify important, relevant information (Abraham et al., 2015).

1.5.2 Patient Acuity Ratings in Handover Tools

Patient acuity ratings, also called illness severity ratings, are commonly included in handover tools. The I-PASS tool features three illness severity ratings, “stable”, “watcher”, and “unstable”. Patient acuity ratings are used elsewhere in healthcare to manage patient prioritization. For example, the Canadian Triage Acuity Scale (CTAS), used in Canadian emergency rooms, is an example of an acuity rating that has demonstrated a correlation between higher acuity rated patients having a quicker door-to-physician time than patients with a lower acuity (Jiminez et al., 2003). O’Donnell et al. (2016) demonstrated a correlation between higher patient acuity ratings with increased attention from a specialized clinical team known as the Rapid Response Team, as well as higher rates of transfers to a high acuity unit when compared with patients who had lower acuity ratings. In the context of electronic handover tools, researchers have not studied the use of patient acuity ratings to communicate the patient’s status and urgency of tasks related to the patient’s care. To-date, the validity (e.g., inter-rater reliability) of the illness severity ratings has not been studied extensively. One study found moderate to good agreement between residents and an expert when classifying surgical patients (Gilmore et al., 2017). For the purpose of this study, acuity ratings were considered accurate as reported by the person documenting the action items.

1.5.3 Action Items in Clinical Handover Tools

A key component of electronic clinical handover tools is the ability to document tasks and orders that need to be done in the near future, often called “to-do lists.” For the purpose of this thesis, the term ‘action items” will be used to refer to “to-do lists.” Stein, Wrenn, Stetson and Bakken (2009) used data from an electronic handover tool to classify tasks into *what, where,* *when, why, how,* and *by whom they are to be performed*. More recently, Collins, Stein, Vawdrey, Stetson and Bakken (2011) used the continuity of care document (CCD) classification to classify action items used in physician handover tools that were identified in the literature. The CCD classification has been designed to support continuity-of-care for patients and was created by the international standards organization Health Level Seven (HL7) (Health Level Seven International, 2016; Health Level Seven International, n.d.-b, para 1)[2]. HL7 publishes standards which are used internationally in clinical settings to provide standardized language for EHRs to allow for exchange and retrieval of information (Health Level International, n.d.-a, para 3). The CCD provides categories for documentation of clinical information such as referral documentation, discharge documentation and transfer summaries and thus provides standards for electronic documentation for patient summary information that is exchanged between physicians, care providers, and health organizations (Hosseini et al., 2017). In the study by Collins, Stein, Vawdrey, Stetson and Bakken (2011), CCD categories captured 80% of content in nurse and physician electronic handovers. In their study, twelve additional categories were created to classify the remaining 20%.

1.6 Study Context

In British Columbia (BC), a group of physicians have created an electronic handover tool named "VirtualWard" (Virtual Ward Medicine Corp.) which is based on recommended functions and was structured using the I-PASS framework. This tool is designed to facilitate handover between physicians and can be accessed from a computer, smartphone, or tablet. The tool is in

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[2] Health Level Seven International (HL7) is an organization that provides international standards for clinical information exchange and clinical administrative data capture (Hosseini, Meade, Schnitzius & Dixon, 2016).

use in Vancouver, British Columbia (BC) and Hamilton, Ontario. The tool has been used at large hospital in Vancouver, BC in the internal medicine department since May 2015. At the time of this thesis writing (June 2018), the tool was used only by physicians with the intent for eventual use by multiple clinical professions, including nurses. Using the tool, the end-user can create a summary of the patient and the patient's visit, patient lists, and patient demographic information. The VirtualWard tool uses terminology for classification of patient status whereby physicians can assign four levels of acuity: i) unstable, ii) watch, iii) stable, and iv) ready for discharge. The VirtualWard tool also permits clinicians to enter action items in a checklist format. VirtualWard has multiple functions, however this study focused specifically on the function of action item documentation and acuity ratings. Detailed functions and features of the VirtualWard tool are presented in Chapter 3.

1.7 Problem Statement

Past literature suggests that several components and features of an electronic clinical handover tool should include: key patient identifiers, summary of patients' issues during hospitalization, patients' assessment and treatment plans, and future actions required for the patient. However, no research was identified which has analyzed relationships with other data elements, specifically patient acuity rating.

1.8 Study Purpose and Significance

The purpose of this study was to: 1) classify free-text action items documented in an electronic handover tool using CCD categories; 2) understand patterns of action items in the electronic handover tool; and 3) examine the relationship between action item category and patient acuity rating. An examination of the patterns and relationships between action items and patient acuity may help to support design decisions for electronic clinical handover tools.

1.9 Research Questions

The following research questions and sub-questions were explored in this study:

Research Question 1: What are the categories of action items documented in an electronic clinical handover tool in use on an acute medicine unit?

Sub-question:

1.1 To what extent can the documented action items be represented using the CCD classification system?

Research Question 2: What are the patterns of action items documented in an electronic clinical handover tool in use on an acute medicine unit?

Sub-questions:

2.1 What are the frequencies of action items?

2.2 On average, how many action items are entered per patient?

2.3 On average, how many action items are entered by each physician?

Research Question 3: Is there a relationship between categories of action items and patients' acuity level?

1.10 Theoretical Framework

The theory of *distributed cognition*, which underpins this study, is an approach to cognitive science that speaks to knowledge being known and shared amongst several individuals. For example, when physicians perform care for a patient, they have knowledge about the patient based upon their interactions and care that they must pass on to other physicians during handover. Hutchins is credited for developing the theory of distributed cognition in the 1980's (Furniss, Masci, Curzon, Mayer & Blandford, 2015; Hollan, Hutchins & Kirsh, 2000). Hutchins noted in his studies of cognitive psychology that information processing is generally studied at the individual level, but noticed outcomes were not entirely attributable to a single individual (Hutchins, 1995). For example, Hutchins (1995) noted that when deciding the speed of a plane upon landing, two pilots are required to double check the speeds, but also the cockpit system in a plane 'remembers' the appropriate speeds, demonstrating a combination of computer tools and human memory are required to determine the landing speed of a plane. In addition to the study of navigation of airplane cockpits in like professionals, Hutchins also studied navigation of navy ships in an inter-professional crew. He determined that outcomes were not due to a single navigator, rather, outcomes were due to interactions between individuals and the tools they utilized (Hollan, Hutchins & Kirsh, 2000).

The theory of distributed cognition represented a paradigm shift in thinking about cognition in the 1980s. Accepted theory had previously posited that an individual knew all, and that all relevant information could be contained within one individual. The new paradigm suggests that information lives within the world and amongst many individuals (Hollan, Hutchins & Kirsh, 2000). In this theory, cognitive systems are divided into three components that coexist in the environment together: the individual, resources, and materials (Hollan, Hutchins & Kirsh, 2000). In addition, there are two overarching concepts: 1) boundaries define the unit being analyzed, and a system is comprised of subsystems, and 2) there are events that occur beyond one person's brain, therefore memory and processing of events are influenced by individuals, and internal and external processes that occur in the system (Hollan et al., 2000). Thus, the process of cognition in distributed cognition is spread amongst members of a social group that use internal and external structures over time to influence outcomes at a later time (Hollan, et al., 2000).

One of the most interesting aspects of cognition is cognitive load, which refers to an individual's ability to put mental effort into processing information (Hazlehurst, 2015). A clinician's cognitive load refers to the idea that a finite amount of information can be processed at a point in time and distractions within the clinical environment itself can affect that amount of information that can be processed (Coiera, 2015). For example, a clinician who is focused on caring for an acutely ill patient has a limited ability to process information about other patients. When multiple clinicians are involved in a patient's care, information processing is distributed across the various clinicians' minds (Hazlehurst, 2015). This distribution of information, coupled with cognitive load, results in a risk of miscommunication (Hazlehurst, 2015). Cognitive load will not be examined in this study but is an important concept to consider in the theory of distributed cognition.

In relation to this study, the most important concept is that no one individual can know everything about a patient and a joint understanding can occur if there is shared information across the care team (Collins, Bakken, Vawdrey, Coiera, & Currie, 2011; Hazlehurst, 2015; Hutchins, 1995). Information is presented to one care provider who may present the information to another care provider. The information passed along may be transformed because information is processed and interpreted by individuals in their own manner. Task performance can be affected by information delivery and the quality of information delivered (Hutchins,1995). Furthermore, multiple individuals have information about one patient, and what one clinician deems as a priority for the patient's care may not be another clinician's priority for the patient.

Some researchers suggest that information technology can support individuals to convey their message, provide a forum to engage in dialogue with others, and allow for information exchange to inform actions (Boland, Tenkasi and Te'eni, 1994; Hazlehurst, 2015). When distributed cognition is successful, individuals are able to understand how an individual's actions impact the outcome, and the interdependencies that are present and affect the outcome (Boland et al., 1994).

In the context of this study, information obtained by a variety of physicians must be communicated between physicians using the VirtualWard tool. If physicians are able to communicate the priority of action items the patient requires, all physicians on the team will understand the priority information communicated during handover (Hollan, Hutchins & Kirsh, 2000). Using the theory of distributed cognition to set the context for this study allows for the assumption that shared information can influence a patient's care and allows for the assumption that if a physician wants the information about a patient's care communicated as a more urgent priority, the urgency will be documented as a higher acuity. This study provides a characterization of 'what' is being communicated about patients at different levels of acuity. While this study does not examine the impact of this communication, it lays a foundation for future research in the area.

1.11 Chapter Summary

Electronic clinical handover tools may provide increased clarity and structure to clinical handover by decreasing information loss and miscommunication, improving the quality and quantity of information presented during handover, and thereby decreasing miscommunication between clinicians and adverse events for patients. There has been limited research to examine the structure and use of specific components of electronic handover tools. This study will examine one electronic handover tool, VirtualWard, to understand the following: 1) the degree to which free-text action items documented in an electronic handover tool are able to be categorized using the CCD; 2) the patterns of action items in the electronic clinical handover tool; and 3) the relationship between action item category and patient acuity rating.

Chapter 2: Literature Review

2.1 Introduction

In this chapter the literature review is presented. Literature related to distributed cognition is presented first, followed by a discussion of the literature on handover in general, in nursing and in medicine. The final section reviews recommendations for best practices in handover including design and use of electronic handover tools.

2.2 Literature Review Methods

A literature review was performed to examine relevant research published up to August 2016. PubMed, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Medline databases were searched using the following search terms in varying combinations with Boolean operators: “handover,” “electronic handover,” “handoff,” “checklist,” and “distributed cognition.” Search terms were based on database search term concepts, i.e., MeSH terms in the Medline and PubMed databases, and CINAHL terms in the CINAHL database. Literature about clinical handover in both medicine and nursing were included to understand clinical handover in both professions. Seventy-three articles were retrieved from CINAHL using the keywords “handoff” and “checklist,” and 25 articles were retrieved using the keywords “electronic”, “handoff” and “distributed cognition.” One hundred and sixty-one articles were retrieved from PubMed and Medline using the key words “handover,” “electronic handover” and “handoff” and “distributed cognition.”

Abstracts considered for review were from peer-reviewed journals and included primary sources, secondary sources, and conceptual/theoretical sources. Systematic reviews, quasiexperimental studies, before and after studies, retrospective studies and opinion pieces were found. Article abstracts in English with a focus on handover and quality of care, handover and handover tools were included. Articles were further reviewed if the abstract was relevant to establish an understanding of how handover has contributed to patient safety or if the use of handover tools was studied. Finally, articles were included if they discussed the application of distributed cognition in the context of healthcare communication and patient safety. Articles which focused on the use of checklists in areas such as the surgical area (e.g., operating room time out) were excluded as they were focused on the use of checklists that captured information *before* procedures, rather than the flow of information between events. The title and abstract of each article was reviewed (n=161). Only articles published in English addressing handover and quality of care (n=7), handover and handover tools (n=19) and distributed cognition in healthcare (n=7) were included. The earliest publication date of the articles found was 2002.

2.3 Distributed Cognition and its Use in Health Informatics

As discussed in Chapter 1, Hutchins first described the theory of distributed cognition in the 1980's and the theory was largely applied to describe work processes in the context of the airline and shipping industries up to 2000 (Hollan, Hutchins, & Kirsh, 2000). More recently, distributed cognition theory has been taken up in healthcare and used to understand communication pathways in the healthcare system in the area of priority setting, design of health systems and technology, and communication (Krieger et al., 2016; Rajkomar, Mayer, & Blandford, 2015; Collins, Bakken, Vawdrey, Coiera, & Currie, 2011; Hazlehurst, Gorman, & McMullen, 2008). Hazlehurst, Gorman, and McMullen (2008) posit that health informatics is guided by cognition, and thus the theory of distributed cognition can be applied in healthcare.

2.3.1 Distributed Cognition and Priority Setting

When enacted in a healthcare setting, distributed cognition results in work carried out by actors and tools, and rules and understanding between individuals guide how clinicians interact. Together, these components make up an activity system. An activity system requires coordination in order to achieve a common goal and can be affected by patterns of communication-informing behaviour. When communication failures occur, the activity system needs to be examined to understand where breakdowns in coordination of the activity system occurred (Hazelhurst, Gorman & McMullen, 2008; Hazelhurst, McMullen, Gorman, 2007). The human brain redistributes the information that is deployed based on the perception of priority. If the priority of the information is not clearly communicated, its priority may be lessened and the action of the activity system may be less effective (Hazlehurst, Gorman & McMullen).

2.3.2 Distributed Cognition in the Design of Health Systems and Technology

Hazelhurst (2015) suggests that distributed cognition can be used to understand health care system processes because healthcare knowledge is shared amongst individuals, therefore one individual housing all knowledge may lead to cognitive overload. Applying distributed cognition to process design where coordination of clinicians is involved may increase patient safety (Hazlehurst, 2015). Coordinating clinicians and their communication tools can decrease communication errors, thereby increasing the accuracy of information communicated about a patient (Hazlehurst, 2015; Collins, Stein, Vawdrey, Stetson & Bakken, 2011). Hazlehurst (2015) points to the utility of a distributed cognition lens in the design of health information technology that can support the redeployment of information. As electronic health records increase in use, more clinicians are sharing information in a common space, and sharing information in a different way than when healthcare records existed purely on paper. Design of electronic health records should occur with consideration of the possibilities of how new communication errors can occur in an electronic space. For example, systems should be designed so that all clinicians can find relevant information rather than one clinician documenting information in a part of the electronic record that another clinician is not expecting the information to be located. Hazlehurst emphasized the need to bring an awareness around how distributed cognition occurs amongst healthcare clinicians in order to support the successful design of electronic health records.

2.3.3 Application of Distributed Cognition in Research

In healthcare, Hazlehurst, McMullen, and Gorman (2007) and Collins, Bakken, Vawdrey, Coiera, & Currie (2011), grounded their health informatics studies in the theory of distributed cognition and used the theory as a basis for explaining the unit or system that was being studied. Four studies used distributed cognition as a framework for their thematic analyses: Two studies used the theory to develop categories of observed tasks in order to classify teamwork in the context of emergency response training (Rajkomar, Mayer & Blandford, 2015) and home hemodialysis use (Rybing, Nilsson, Jonson & Bang, 2016). In the study by Hazlehurst, et al. (2007) the researchers observed the process of cardiac surgery and identified patterns which were then thematically analyzed and coded into events that were expressed as time taken to complete the task. A more recent study by Krieger et al. (2016) used distributed cognition as a framework to thematically analyze interview data about shared decision making for patients with cancer. All studies concluded that the theory of distributed cognition was applicable to their study context, and helped the researchers understand how information is distributed amongst clinicians.

Overall, distributed cognition provides a useful framework for understanding communication and priority setting amongst clinicians. In this thesis, the concept of priority setting is captured by clinicians' indication of the patients' acuity level, and the VirtualWard tool is the communication process. Cognitive load is not measured in this study, but provides a perspective for examining the content of the handover action items. In the next section, studies that examined handover and the use of electronic handover tools will be presented.

2.4 Clinical Handover

Clinical handover is communication about patient information that occurs between clinicians (Coiera, 2015; Flemming & Hubner, 2013). Handover is one way in which information is distributed amongst clinicians. Handover occurs for clinicians in several care settings, for example, a shift-to-shift handover between two or more clinicians, or transfer of a patient to another facility. Handover is done in varying locations such as the patient's bedside, outside of a patient's room, via telephone, or in a private meeting room area (Johnson, Jeffries & Nicholls, 2012). Millions of handovers between healthcare practitioners occur each year (Abraham et al., 2015, Johnson, et al., 2012), and nurses perform the majority of handovers (Johnson, Sanchez & Zheng, 2015). There has been an increased frequency of handover for physicians due to an increase in the staffing of night-float coverage and cross-team coverage of patients in hospital settings (Vawdrey, Stein, Fred, Bostwick & Stetson, 2013). This is related to directives in the United States and Canada since 2003 that have decreased the number of consecutive hours medical residents can work in an attempt to reduce errors related to sleep deprivation, but this has led to an increase in the frequency of handovers (Guilbeault, Momtahan & Hudson, 2015; Mukhopadhyay et al., 2014). Clinical handover is completed in several formats, including verbal, written, or a combination of both (Flemming & Hubner, 2013; Collins, Stein, Vawdrey, Stetson & Bakken, 2011). Clinical handover may be synchronous (e.g., face-to-face), or asynchronous (e.g., written and read at a later date/time) (Flemming & Hubner, 2013; Collins et al., 2011). Historically, clinicians have preferred face-to-face communication for handovers because it provides an opportunity for interaction and a mutual understanding to be established (Flemming & Hubner, 2013; Collins et al., 2011). However, synchronous communication is subject to interruptions which may also contribute to gaps in communication and information not being communicated between practitioners (Flemming & Hubner, 2013).

2.4.1 Handover in Nursing

Nurses perform the majority of clinical handovers in hospitals and handover is a part of a nurse's professional responsibility to help ensure that continuity-of-care is maintained for patients. Handover allows for important information about the patient to be communicated (Johnson, Sanchez & Zheng, 2015). Handover in nursing not only serves as a means to communicate about a patient's status and care needs, but also as team building, a forum for socialization of new nurses, and an opportunity for patient and family involvement in their own care (Abraham et al., 2016; Johnson et al., 2015). Handover has also been found to promote patient-centered care, communicate adverse events, and improve the accuracy of care delivered to the patient (Johnson et al., 2015).

Utilization of a handover tool for nursing was found to be valuable if it decreased the time nurses spent preparing handover information and communication, and workflow efficacy was improved when a nursing handover tool was used (Abraham et al., 2016). However, barriers in nursing handover include time and environmental constraints, communication problems, variations in computer literacy, satisfaction and trust in the handover tool, and problems related to hierarchy that exists in the health care system (Abraham et al., 2016; Keenan, Yakel & Marriott, 2006). Additional barriers to nursing handover will be discussed in Section 2.7.1.

2.4.2 Handover in Medicine

Like nurses, physicians perform handover as part of their daily work. Physician handover has been found to be unstructured and unstandardized (Li, Ali, Tang, Ghali & Stelfox, 2012.) Handover for physicians is influenced by cultural and environmental factors including: 1) environmental setting can cause interruptions and contribute noise that may impact physicians' ability to hear the information being presented, 2) the hierarchal nature of medicine may provide opportunities for power differentials to be enforced, 3) language barriers that exist due to differences in physicians' primary spoken language, and language barriers that result in misunderstood abbreviations or colloquialisms, and 4) the opportunity for synchronous communication to allow for information clarification and elaboration to occur (Solet, Norvell, Rutan & Frankel, 2005). In a recent study, (Lee, Phan, Dorman, Weaver & Pronovost, 2016), researchers found that physicians' who had a belief that they had personal responsibility for the patient also had higher perceptions of patient safety. Barriers to handover in medicine will be discussed in Section 2.7.1.

2.5 Clinical Handover and Communication Errors

Handover of care, in nursing and medicine, from one clinician to another is an opportunity for risk of communication errors (Hern et al., 2016), also known as miscommunication (Coiera, 2015). Miscommunication occurs when information communicated from one clinician to another is not interpreted as it was intended, or not all information communicated from one clinician is delivered to another clinician (Coiera, 2015). Communication errors during handover have been shown to contribute to errors in patient care (Abraham et al., 2015) and are one of the leading causes of serious medical errors (Starmer et al., 2014). Clinical handover can result in gaps in information or misunderstandings in the information communicated (Johnson, Jefferies & Nicholls, 2012).

Asynchronous handover techniques, such as written handover, are not a desirable method when used in isolation (Flemming & Hubner, 2013) as they do not allow for verbal and visual cues to occur (as cited in Johnson, Jeffries & Nicholls, 2012; Li, Ali, Tang, Ghali & Stelfox, 2012). A combination of synchronous and asynchronous communication is seen as the desirable method for handover of patients between healthcare practitioners (Johnson et al., 2012; Li et al., 2012). This synchronous and asynchronous combination has been deemed ideal because only 2.5% of information is retained after five purely verbal handovers (Johnson et al., 2012) while a combination of both synchronous and asynchronous communication can improve communication during handover (Mukhopadhyay et al., 2014).

Handover is documented about 50% of the time, and Hern et al. (2016) suggest that handover of care is a vital point of transition in a patient's care; therefore, its documentation needs to occur in the patient's chart. Johnson, Sanchez and Zheng (2015) found that nurses value the presence of a computerized written record of handover as it provides an electronically retained record of what was documented for a handover and a central repository of handover information, which in turn allows for accountability and evidence of the information that was documented. Indeed, the Australian Commission on Quality and Safety, in a document about handover, has recommended the documentation of handover in the patient's chart (Australian

Commission on Quality and Safety, n.d.). Handover done verbally is not documented, and handover done via paper is often discarded by clinicians, and both these methods leave no trail that handover has been carried out between clinicians. In the future, if the requirement is in place for documentation of handover or if there is a legal obligation for handover documentation, it will be helpful to have clinical handover content documented in a patient's chart.

2.6 Methods to Improve Handover

Handover serves many purposes in healthcare and is a dynamic process that has opportunity for communication clarity but also miscommunication between clinicians. Coiera (2000) emphasizes the need for understanding communication and how its dynamics impact information systems' design. Complexities of human communication need to be considered when an electronic handover tool is designed because failures that result from miscommunications can contribute to adverse clinical events (US Joint Commission, 2016; Coiera, 2015; Starmer et al., 2014; WHO, 2007). Examples of complexities involved in human communication include differing perceptions of information presented, cognitive bias influenced by the clinician's personal perception of the information, differing knowledge and experiences between the individuals and distractions the clinician may be experiencing thereby impacting their ability to devote attention to the information communicated (Coiera, 2015).

2.6.1 Improvements to the Process and Structure of Handover

Various organizations have put forward recommendations to improve the handover process including the following: decrease steps in the handover process, build redundancies in the care process (i.e., ensure the presence of critical information at different steps of the patient's care), embed forced functions (e.g., embedding reminders for handover documentation, or not allowing electronic handover documentation to be completed until pre-determined pieces are filled out), and utilize the perspective of human factors (i.e., understanding how humans make errors) (WHO, 2007). The US Joint Commission recommends redesigning strategies and processes used in handover alongside standardizing communication (Abraham et al., 2015). Such standardization efforts have seen structure introduced into handover in formats such as templates, spreadsheets, checklists, and mnemonics (Abraham et al., 2015).

The majority of handover systems in literature reviewed by Flemming and Hubner (2013) utilized a structured format to capture information. Structured content approaches to handover have been shown to deliver a more complete package of information between healthcare providers during handover (Johnson, Jeffries & Nicholls, 2012). Structures within handover tools often include patient demographics, patient history, clinical course, and "to do" lists (Flemming & Hubner, 2013). Despite structured formats being implemented into the handover processes, the adoption and consistency of the use of structured handover has been varied (Starmer et al., 2012).

Although Starmer et al. (2012) found structured handover tools decreased adverse events, structure in electronic handover tools can have a negative impact on clinicians and their work. Structure, when compared to a free-text option in electronic handover tools was found to increase the amount of time clinicians spend entering information in the handover tool by 60% (Suominen et al., 2015). Also, the electronic handover tool implemented must have structure that is congruent with the needs of the practice context. For example, areas with rapid turnover, such as the emergency department, require handover structures which focus on the essential patient information, such as the patient condition and plan. Focusing handover content on a detailed care plan would not match the context of the emergency department, and may lead to the handover tool not being utilized if it does not meet the clinical area's needs (Johnson, Jeffries & Nicholls, 2012).

2.6.2 Mnemonics to Improve Clinical Handover

Structure in handover tools can be provided through the use of templates of mnemonics. Mnemonics are used in high-risk, high-impact industries that aim to achieve high quality outcomes despite the high potential for errors that result from unexpected events (Starmer et al., 2012). For example, the aviation industry uses mnemonics to guide pilots through a checklist when a decision must be made in a time-sensitive situation (Starmer et al., 2012). Verbal mnemonics standardize communication and are used because they are catchy, stimulate visual mental images of the information being described, and act as memory aids (Starmer et al., 2012).

Twenty-four different handover mnemonics were identified by Starmer et al. (2012); the three most common were SBAR (Situation, Background, Assessment, Recommendation), SIGNOUT (Sick, Identifying data, General hospital course, New events of the day, Overall health status, Upcoming possibilities with a plan, Tasks to be completed), and I-PASStheBATON (Introduction of self, Patient identifiers, Assessment, Situation, Safety concerns, Background, Actions, Timing, Ownership, Next steps) (Riesenberg, Leitzsch & Little, 2009; Hern et al., 2016).

Starmer et al. (2014) studied the use of the I-PASS mnemonic structured electronic-based handoff tool and education about best practices for handoff and demonstrated a decreased rate of medical errors by 23%; More than five thousand (n=5,561) handovers were done prior to the I-PASS intervention compared with 5,224 handovers that were done after the I-PASS intervention.

Baseline and post-data on length of stay and patient demographics were similar in the I-PASS intervention and baseline groups. The authors found that prior to implementation of the I-PASS bundle there were 24.5 errors per 100 admissions compared to 18.8 errors per 100 admissions after the implementation (p<0.001). In addition, they found that there were 4.7 preventable adverse events per 100 admissions pre-I-PASS versus 3.3 events post-I-PASS implementation (p <0.001). In another study with nurses who used SBAR in a hospital, there was a decrease in adverse events from 90 to 40 events per 1,000 patient days, and a decrease in adverse drug events from 30 to 18 events per 1,000 patient days (Starmer et al., 2012). Despite the successful reduction of adverse events with the use of I-PASS no literature at the time of this review was identified that examined the uptake and impact of the I-PASS tool outside of the original study.

2.7 Electronic Clinical Handover Tools

In their systematic review, Flemming and Hubner (2013), reviewed 22 articles on electronic handover, of which 59% were physician oriented, 18% were multidisciplinary oriented, 14% physician and nursing oriented, and 9% were nursing specific. The use of an electronic handover tool has been shown to increase the quantity and quality of data in handover, increase the number of fields completed in the handover tool, and improve the accuracy and up-to-date information present in the handover (Flemming & Hubner, 2013). This increase in quality information can increase information retention, therefore allowing essential information to be passed between clinicians (Flemming & Hubner, 2013). One study demonstrated that an electronic-based handover tool improved clinicians' workflow (Van Eaton et al., 2005).

2.7.1 Design and Implementation Considerations for Electronic Handover Tools

Some researchers suggest that handover tools should either be built into the EHR or integrated with the EHR to support more effective handover rather than being stand-alone, separate applications (Michelson, Ho, Pelletier, Ayubi & Bourgeois, 2015; Vawdrey, Stein, Fred, Bostwick & Stetson, 2013). Integration of an electronic handover tool with an EHR was found to be useful if the information was up-to-date, had complete patient information, provided a view of the patient's clinical picture, had elements to aid in clinical decision making and was amalgamated in one location (Flemming & Hubner, 2013).

Despite several positive outcomes reported following an electronic handover tool implementation, there have been some negative outcomes. One electronic handover tool was abandoned because the information in the tool did not contain up-to-date information and clinicians' work was duplicated because they had to enter the information in the chart and then into the tool (Flemming & Hubner, 2013). Mobile-based handover tools had poor user acceptance if they were not user-friendly and took longer to use than pen and paper or to have a face-to-face conversation (Michelson, Ho, Pelletier, Ayubi & Bourgeois, 2015; Pryss, Mundbrod, Langer & Reichert, 2015). Usability issues have caused electronic handover tools to be abandoned for the following reasons: the inability to capture sufficient patient information, inability to personalize the information captured, out of date information in the electronic handover tool, and clinicians performing duplicate work because they have to enter information both into the chart and then into the tool (Michelson, Ho, Pelletier, Ayubi & Bourgeois, 2015; Flemming & Hubner, 2013).

2.7.2 Content in Nursing and Physician Handover

In a literature review, Collins, Stein, Vawdrey, Stetson, and Bakken (2011) found a 46% overlap in information captured in handover in nursing and handover in medicine. Both nursing and medicine handover captured general handover elements such as problems, diagnosis, procedures, treatments, clinical judgments, and physical exam findings. However, for both nursing and medicine, components included in handover reflected the needs of the area in which handover was being done (e.g., emergency room versus inpatient unit). For both disciplines, handover was structured around the clinical needs of a specialty area; for example, a medical ward may capture a patient's discharge planning information but the intensive care unit may be more focused on the patient's immediate treatment plan needs within the next 24 hours. Collins et al. (2011) point out that structuring a single handover tool to meet the needs of nursing and medicine may not serve the needs of both disciplines (Collins, Stein, Vawdrey, Stetson & Bakken, 2011). However, the creation of a tool that overlaps both disciplines and encompasses other health care disciplines may decrease redundancy and information loss (Collins et al., 2011) thereby improving inter-disciplinary communication. A handover tool that would include input from all the clinicians involved in a patient's care could support a multidisciplinary approach, and allow different disciplines to view rationale and information from other disciplines (Collins et al., 2011).

2.7.3 Action Item Lists in Handover for Physicians

A major requirement of an electronic handover tool is its ability to support physicians in the organization of their tasks (Pryss, Mundbrod, Langer & Reichert, 2015). Clinicians' work revolves around completing tasks to provide the care needed by their patients. Pryss, et al.,

(2015) suggest that for physicians' work to be supported with a mobile or electronic tool, tasks need to be located in an overview list form, be displayed in a format that allows them to easily keep track of the task and its status (e.g. complete or incomplete), and if possible, the progression of the task needs to be easily viewed. In addition, the task list should be easily shared between individuals, allow for multi-user contributions, and highlight upcoming tasks. Pryss et al. (2015) found users would benefit from a visual notification of the status of the task, for example, the use of different colours to represent the task's status.

Stein, Wrenn, Stetson and Bakken (2009) examined and coded physicians' tasks from a handover tool, and found the most common tasks physicians entered in their task lists were assessment actions, then orders, communication, and performance of a procedure. Stein, Vawdrey, Stetson and Bakken (2010) performed a study over two sites and also found assessment tasks were the most commonly entered free-text tasks by physicians. In a subsequent study Stein et al. (2010) examined the International Standards Organization's (ISO) list of types of nursing actions, (action, target, site, means, and recipient of care) and found these categories similar to the types of tasks physicians had entered. A clinician and an informatics-trained non-clinician coded the tasks, and tasks that were deemed incomprehensible by the two researchers were excluded from the study (Stein, Vawdrey, Stetson & Bakken, 2010). Stein et al. recommend that, in the future, natural language processing techniques (use of computer algorithms for free-text coding) be used to code the free-text tasks rather than manually by humans, or by using pick lists or drop-down boxes.

The use of ISO to classify handover tasks is not the only standardized content that has been used to examine handover content. The CCD standard developed by HL7 was used by Collins, Stein, Vawdrey, Stetson and Bakken (2011) to classify action items in physician handover. The purpose of the CCD is to standardize patient summary information that is exchanged between providers and organizations in electronic health records and provide essential patient information for continuity-of-care (Hosseini, Meade, Schnitzius, & Dixon, 2016). The categories used by the CCD document include the following: allergies, medications, problems, procedures, results, advanced care plan, encounters, family history, functional status, immunizations, nutrition, mental status, vital signs, social history, plan of treatment, payers section, and medical equipment (Health Level International Seven, n.d.-b). Collins, Stein, Vawdrey, Stetson and Bakken (2011) created 12 categories (admission demographics, fluid balance, education, updates, pain management, orders, psychosocial concerns, anticoagulation status, prophylaxis, hospital course, past medical/surgical history, and consultations) to capture content that was not classifiable using CCD categories. Collins et al. (2011) were the first to publish categorization of patient handover content using CCD categories; however, their research did not specifically examine the categorization of action items documented in electronic handover, nor did they explore relationships between clinical handover data elements.

2.7.4 Data Standards and Interoperability: Relevance to Electronic Hanover Tools

The use of standardized languages for clinical handover could support consistent use of terminology in handover, which would allow for a one-to-one comparison of documentation. When documentation is comparable, outcomes can be compared for nursing and medicine (Keenan et al., 2002). The CCD categorizations were put forth by the international standards organization Health Level Seven (HL7). The purpose of HL7 is to provide standards for data that are captured electronically in healthcare in order to exchange information between two electronic systems (known as interoperability) (Health Level Seven International, n.d.-a). Interoperability allows for clinical information to be exchanged between care providers and between health organizations but requires standard language to exist so that different electronic health information systems can communicate (Health Level Seven International, n.d.-a). Standardized information exchange can improve continuity-of-care and reduce disparities in patient information (Hosseini et al., 2016) and the continuity of care documentation (CCD) standard may provide an infrastructure to support the advancement of standards for electronic clinical handover tools.

2.8 Summary

In summary, distributed cognition is a theory which can be used in examining clinical handover between clinicians about patients, which occurs millions of times each year. To date, there is no international standard for handover and limited research has examined the content of electronic handover tools. An understanding of the purpose of handover in health care, the barriers in using electronic handover tools, and standardizing language within an electronic tool will enable better design of these tools. Electronic handover tools with these elements considered in their design may improve communication between clinicians. Furthermore, increased interoperability of electronic handover tools with EHRs may help to decrease miscommunications between clinicians.

Chapter 3: Methodology

This chapter provides an overview of the study design, study sample, data collection, data coding and analysis methods.

3.1 Research Question and Hypothesis

Research Question 1: What are the categories of action items documented in an electronic clinical handover tool in use on an acute medicine unit?

Sub-question:

1.1 To what extent can the documented action items be represented using the CCD classification system?

Research Question 2: What are the patterns of action items documented in an electronic clinical handover tool in use on an acute medicine unit?

Sub-questions:

2.1 What are the frequencies of action items?

2.2 On average, how many action items are entered per patient?

2.3 On average, how many action items are entered by each physician?

Research Question 3: Is there a relationship between categories of action items and patients' acuity level?

3.2 Study Design

In this study, a retrospective descriptive design was used and a sequential qualitative, quantitative mixed methods analysis was performed (Polit & Beck, 2012). The same data set was used for both phases. In phase one, the qualitative phase, free-text action items were categorized using CCD categories. In phase two, two quantitative analyses were performed: first, the frequencies of the categorized action items were computed, second, the relationship between acuity ratings and type of action items was examined. During analysis it was noted that acuity levels, *unstable* and *discharge* were only rarely used, therefore only *stable* and *watch* acuity ratings were analysed during phase II.

3.3 The VirtualWard Tool

This study examined one specific electronic clinical handover tool, VirtualWard, which is accessible from a computer, smartphone, or tablet, and was the only electronic handover tool in use at the time of this study. The VirtualWard tool requires a two-step authentication to protect patient information before the clinician can access the tool. After this first sign-in step, a code is sent to the clinician's device using the application "DuoMobile' (Duo, United States). The clinician then enters this unique, valid for one-time, use code before they gain access to the VirtualWard tool. The two-step authentication provides an extra layer of security to access VirtualWard. Once the clinician has logged in to the VirtualWard tool, they can input patient demographic information. The clinician can also input the "reason for referral," which can function as the patient's admitting diagnosis, the location in the hospital, the assigned physician, the "status" indicating whether the patient is an admission or a consult, and the patient's "health rating" which is the VirtualWard term for "acuity rating."

In the VirtualWard tool, the patient's acuity rating is classified from most severe to least severe, using the categories *unstable, watch, stable,* and *discharge*. The physician can create a personalized patient list from the patients entered in VirtualWard, which allows them to view only the patients they are responsible for. Figure 3.1 shows a screenshot of the patient list view of the VirtualWard tool (with mock data).

VirtualWard uses headings modeled after the I-PASS mnemonic, “**I**llness and severity”, “**P**atient summary”, “**A**ction list”, “**S**ituation awareness and contingency plans”, and “**S**ynthesis by the receiver.” Illness and severity are represented by acuity rating in Virtual Ward, a patient summary section is available to document one to two sentences to summarize the patient’s history of presenting illness and any pertinent medical diagnoses, and the “to do” section allows for the documentation of action items or plans by the clinician.

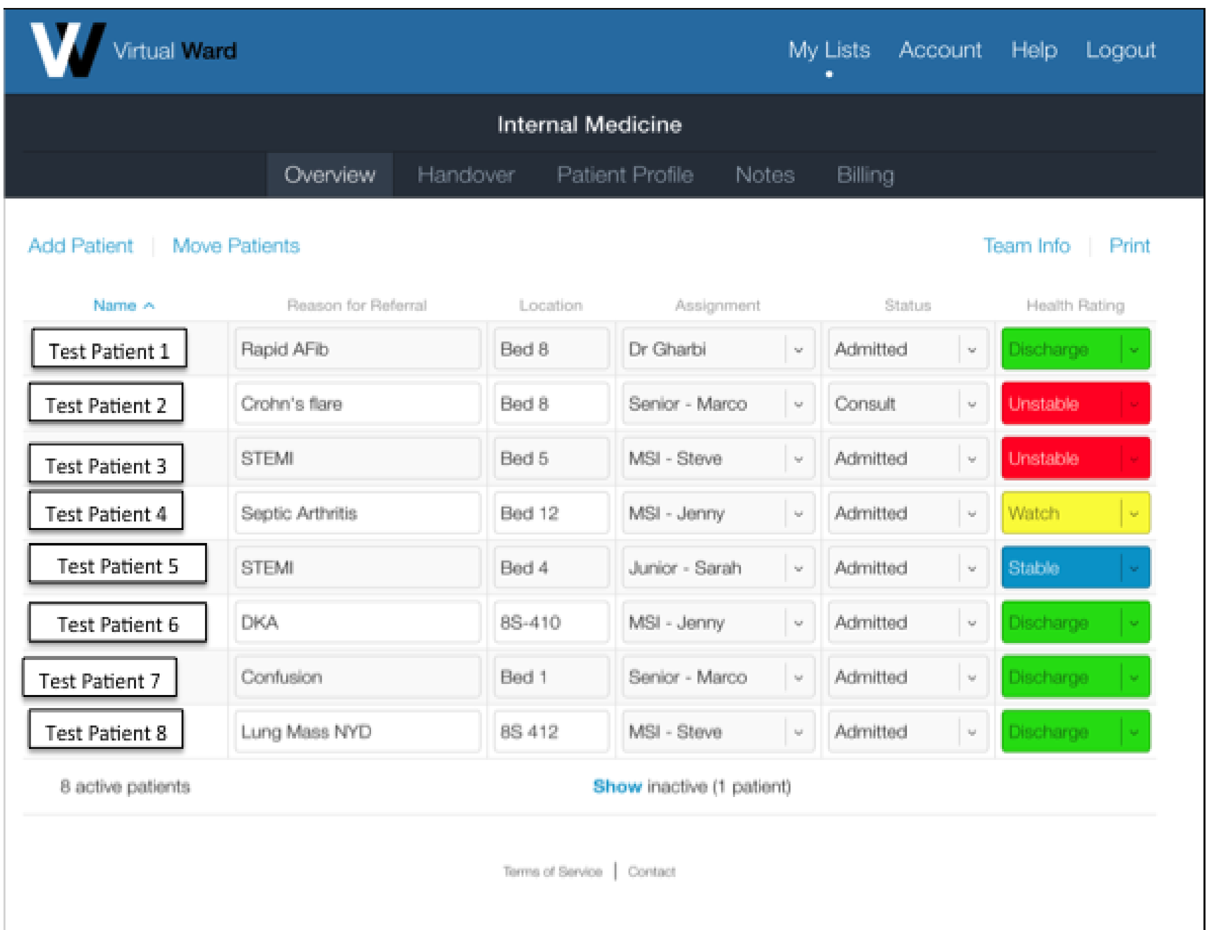

Figure 3.1 Screenshot of VirtualWard Tool with Mock Patient Data

For each patient, a summary list of active issues, and a "to do" list can be created. The VirtualWard tool uses the terminology "to do," for the individual items listed in the "to do list" section, however, as described earlier, in this study the "to-do" items will be referred to as *action items*. The action items list in VirtualWard is a free-text list-based entry of activities that the physician has identified as needing to be completed, such as medical imaging and laboratory tests. There is a time stamp in the data warehouse of when the action item was entered, whether the action item was resolved, and when it was resolved. Multiple clinicians can contribute and enter information and action items for a patient in order to facilitate handover between physicians by allowing for communication of incomplete tasks or necessary follow-ups for a patient. The patient summary, active issues, and "to do" list in VirtualWard can be seen in Figure 3.2. All data entered into the VirtualWard tool are stored as encrypted data in a data warehouse that is managed by VirtualWard which is located in Ontario, Canada.

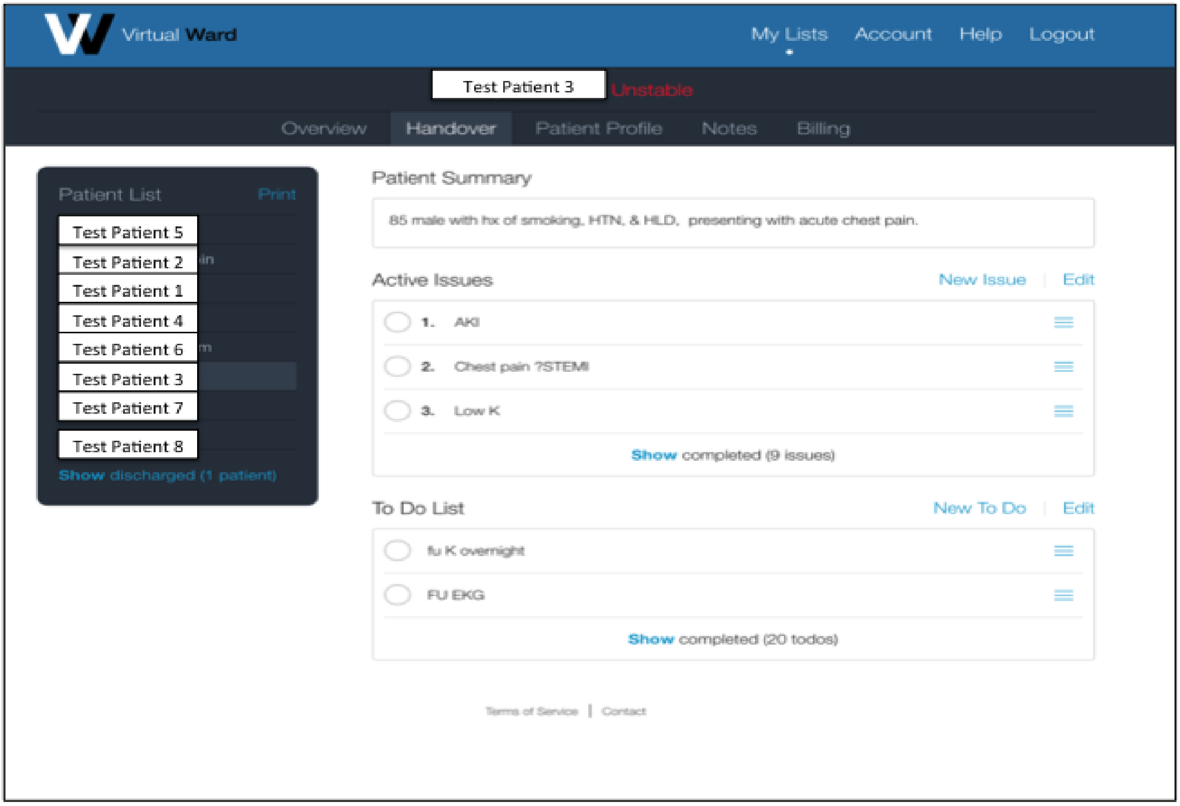

Figure 3.2 Patient Summary, Active Issues, and “To Do” List in VirtualWard

3.4 Data Source

VirtualWard has been in use by physicians on the medical ward since May 2015, a surgical ward since October 2015, and an HIV specialty unit since May 2016. The medical ward is also a Clinical Teaching Unit (CTU). A focused data extract was obtained with only relevant data extracted including: Action items, patient acuity status, patient sex, and age of patient at time of action item entry. The VirtualWard database manager created and performed the query to extract the data. Data were extracted for patients admitted to the medical ward/CTU between July 1, 2015 and June 30, 2016. Data were excluded from analyses if any of the following reasons were present: i) the action item was incomplete (e.g., ref) or incomprehensible (e.g., ‘asdf’), ii) no acuity rating was listed for the action item, and iii) no action item was entered but an acuity rating was present.

The date July 1 was chosen because this is when new resident physicians enter practice. A retrospective sample of data comprising a year’s worth of data was chosen for two reasons: 1) to allow for a large number of action items to be gathered as this encompassed a one-year timeframe, and 2) to allow for users of VirtualWard to gain familiarity with the tool and use the tool more regularly for handover documentation since its implementation in May 2015. The medical ward/CTU was chosen for this study because of the wide range of patients cared for, rather than focusing on a specialty population. A large proportion of patients on the medical ward/CTU have chronic illnesses, such as diabetes and cardiac disease. The ward does not admit patients requiring critical care support. There are four teams on the ward. Each team is comprised of one attending physician, two residents, and two medical students. Some teams will also have a Fellow. Therefore, each team has between five and six members, and each month, up to 24 physicians will be caring for the 50 patients who are admitted to the ward. These attending physicians rotate monthly, where one physician will be overseeing care during weekday daytimes with different attending physicians covering nights and weekends. The attending or training physicians are responsible for handover, which occurs at least twice daily and is performed monthly when handover of patients is done with a new team. All team members had access to VirtualWard. Over the year, there are at least 96 residents and 96 medical students who rotated through the ward. There were approximately 36,500 handovers carried out (i.e., Total handovers (regular) = 2 per day*50*365 = 36,500).

3.5 Phase I Data Analysis: Action Item Classification

The first phase, qualitative data analysis, addressed research questions 1 and 2: 1) What are the categories of action items, and 2) At what frequencies are the categories entered in VirtualWard? These data were collected as a list of free-text action items to provide an understanding of what types of free-text items are entered as action items. Data were obtained with patient names de-identified (e.g. no patient name was present in the data), and a unique numeric identifier was assigned to each unique patient by the VirtualWard database manager. Patient age, sex, and acuity rating at the time the action item was created were also obtained.

Classification of action items was done by two individuals, the researcher (PL) and the researcher's supervisor Dr. Leanne Currie (LC). Categories for classification were derived from the CCD classification framework that describes information contained in an electronic patient summary document, but not specifically in an electronic handover. These categories were extracted on October 13, 2017 (Health Level Seven International, 2016) and include the following: advanced care plan, education, functional status, medications, plan of treatment, problems, results, social history, and vital signs, mental status and fluid balance (Health Level Seven International, 2016). Unfortunately, no clinical definitions for these terms were available, therefore definitions for these terms were created by the two coders as the coding process was progressing. See Table 3.1. Examples of the free-text action items are provided in the table to show how the terms were classified. During coding, it was evident that several items could not be mapped to the CCD categories, so two new categories, 'Consults' and 'Other', were created (see Table 3.2). Collins, Stein, Vawdrey, Stetson, and Bakken (2011) categorized content of physician and nurse handover, and their categorization was examined for categories that could be used to classify the un-mapped action items. 'Consults' was a handover category developed by

Collins, Stein, Vawdrey, Stetson, and Bakken (2011) and used in this study. Action items that did not fit a category developed by Collins, Stein, Vawdrey, Stetson, and Bakken (2011) or CCD categories were classified as ‘other’ for this study. Eight CCD categories were excluded from the analysis because they were related to data that would be found in other sections of the VirtualWard tool. These eight CCD categories were: allergies, procedures, encounters, family history, immunizations, nutrition, payers section and medical equipment (Health Level International Seven, n.d.-b).

Table 3.1 Definition of CCD Classification Category with Examples of Action Items

CCD Classification	Definition	Examples
Advanced Care Plan	An action item relating to a patient's wishes for their care or code statues. The patient's wishes around care they want to receive if they have a cardiac or respiratory arrest and is information often contained in an advanced care plan.	"Code status discussion", "Full code, revisit code status"
Education	Order education for patient and/or family. Examples are discharge teaching and education about the patient's medical condition.	" counsel contraception", "Diabetic teaching (in progress)"
Functional Status	Action items that describe a follow up with a consulting allied health or non-MD speciality, for example physiotherapy or occupational therapy, to assist in the patient's care. These consults are frequently requests for mobilization assessments or assessments centering around activities of daily living.	"Social work to see re:housing", "Awaiting consult with incontinence RN - US GU tract done (no significant findings)"
Medications	Ordering or reviewing medication initiation, changes, or stoppages.	"titrate pain meds", "Warfarin - re-start anti-coagulation when stable" "F/u on BP control - amlodipine 5mg started Aug 10. NB - moderate AS.", "d/c iv phosphate"
Plan of treatment	Action items related to the plan or things to do for the patient's stay or discharge. Action items included: ordering IV fluids/lines (insertion or maintenance of a line or intravenous (IV), or pertaining to the IV fluids), ordering blood (blood products i.e. red blood cells, platelets to be ordered,), wound care treatment plan or management, and discharge related action items included those in order for a patient to either go home, for example discharge planning and coordination of resources for patient's discharge. This category also includes plans of care for while the patient is admitted. These action items detailed a physician's thought process on the plan of care for the patient during their admission were classified in this category. Action items that were not plans of care that could be categorized under any other categories were placed into this category. Also included were action items related to patient transfer, location of patient transfer or status of a pending transfer if the patient is awaiting transfer to another facility.	"DISPOSITION: at home with partner", "WEEKEND TO DO: pt new desire to go to rehab home, discuss options" "Order PICC", "Re-assess iv fluids" "Transfuse 2 U PRBC's", "Watch hgb - transfuse prn" "monitor respiratory status, adjust lasix/spiro accordingly", "Day pass Aug 5, will be back at 1700 and drain another 5L today" "transfer back to Whitehorse – transfer network aware", "likely to go to ICU tonight" "WCN says wounds better; still need pseudomonas ctrl", "Head wound to heal.. non-drainable"

Table 3.1 Definition of CCD Classification Category with Examples of Action Items (Con't)

CCD Classification	Definition	Examples
Problems	Diagnosis for the patient or description of factors being considered to rule out a diagnosis for the patient (these action items were a physician's thought process in ruling out potential diagnoses on a patient.)	"Pelvic fracture - on decreasing doses of morphine", "Cirrhosis - monitor weight, I/O, Hb" "Identify precipitant: ? Hypovolemia", "Rt thigh pain – Doppler neg for DVT"
Results	Action items where there are results or reports that are generated after being ordered. Action items were categorized in this category if physicians had to follow up after these tests were completed. Order or review of: a test or procedure to test a patient's cardiac function, for example ECG (a test) or angioplasty (a procedure); a test that is not a lab, for example medical imaging; a laboratory test to be done including blood tests, urine tests and other body fluid tests.	"Age appropriate malignancy screen: arrange mammo, c-scope, pap", "Consider bronch if no sputum expectorated for ?TB," "Make sure echo is ordered (May 22)", "needs TEE," "Follow up aTTG, thyroid workup", "Repeat BW for Jul 10: CBC, smear, lytes, Cr, BUN, lactate, CK," "watch for echo report", "F/U 24hr holter," "review MRI head May 25," "F/U hand CT - ? # distal ulna on x ray," "Monitor INR", "Follow up cultures"
Social History	Patient history involving any personal or familial non-medical history. Included in this category are: collateral information required from another health professional or family about the patient, family discussion or involvement around the patient's care.	"Contact pt's community support staff for collateral and d/c plan", "GP collateral re: lasix and spironolactone indication if able" "? wife and kids - see notes in Family History / Patient Profile", "patient brother to visit at 9h30 AM June 22 - would like update"
Vital Signs, Mental Status and Fluid Balance	Action items that stated to order or review ordered vital signs, mini mental status exam (MMSE) and in and out fluid monitoring. Upon further discussion with the researcher's supervisor and examination of the CCD categories, these were split into the following categories: Vital signs for orders pertaining to vital signs, Mental status for orders for a MMSE to be done and fluid balance for in and out fluid monitoring.	"Monitor BP", "Follow daily wts", "Volume assessment per & post HD", "vitals q4h"

Table 3.2 New Classification Category with Definitions and Examples of Action Items

New Classification Category	Definition	Examples
Consult **This is not a CCD category but a Collins et al. category	Consulting another medical speciality to assist in the patient's care or review or follow the plan outlined by another medical specialty to assist in patient's care 11.7% of action items were classified as consults. With this percentage of action items classified as consults it was decided between the researcher and the researcher's supervisor to maintain "consult" as a distinct category.	"Addictions to see", "Neuro consult" "Girdlestone P - ORTHO to attempt Jun 26- Xray Px 24th", "Seizures: Confirm plan for titration with neurology and follow up."
Other (not a CCD category)	Did not fit any categories listed when reviewed by the researcher and researcher's supervisor.	"TP-EIA Px" (Abbreviation for Syphilis Lab test), "G6PD spot test Normal but dapsone listed as an allergy"

The classification process involved several steps. First, the coders each reviewed 10 action items and assigned CCD codes to these. These 10 coded items were then discussed, and the coders came to consensus on the appropriate CCD code. This process was repeated for a total of 100 codes in batches of 10 action items. Once the coders were confident with the coding process, an additional 400 action items were coded independently. The 400 coded items were reviewed for discrepancies and the items that did not have matching codes were discussed until consensus was achieved. During classification, it was found some action item entries contained multiple action items (e.g., “DM II: Will require special authority for lantus and will need to check with SW that is has MSP and PHN”) and these were given multiple classifications by the two coders. Action item entries with multiple classifications were treated as an independent action item in subsequent data analysis.

Not all action items in the data set were able to be classified and these were excluded from analysis for the reasons that follow. Blank action items were an action item that was marked as created in the system but the physician did not enter any text therefore no text was present. In some instances, the free-text only contained the term ‘New to do’. On examination of the software, it was evident that the default free-text was ‘New to do’. Items that had no additional data, and had free-text of ‘New to do’ were also not included. Unintelligible action items were incomprehensible between the researcher and the researcher’s supervisor. Such action items used unintelligible acronyms (e.g., BMD P) and some were key stroke errors that were undecipherable (e.g., asdf). Some of these might have represented keystroke errors, but given that in this study the researcher was not able to communicate with the person who entered the information, there was no opportunity for clarification.

The remaining action items were coded independently by PL and if it was unclear which category the action item should be classified under coder two (LC) was consulted. A random sample of 300 action items were sent to committee member (SHC) who coded these action items for inter-rater reliability. An interclass correlation analysis was performed to determine the inter-rater reliability in coding of action items.

3.6 Phase II Data Analysis: Action Item Frequencies & Relationship to Acuity Level

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 21.0. Examination of the data revealed instances of an action item that did not have the patient's age entered. When age was not documented in the age column, the free-text patient summary was examined to see if 'age' was written as a 'note'. If an age was documented in the patient summary and no age was documented in the action item data, the age from the patient summary was used to populate this missing component. The examination of the action item data revealed instances where several (n=59) patients had multiple ages entered. It is unknown if this resulted from keystroke errors or incorrect data entry by the physician. For these 59 instances it was determined by the coders to use the lowest age entered and to use the age in the action item data set as the correct age for the patient. The rationale for using the lowest age entered was for patients with multiple ages, it was assumed chronological multiple ages were due to the patient having a birthday during their admission. For patients with non-chronological ages it was assumed the age entry was due to user error. One instance did not have an age in either the action item or patient summary data, and that case was excluded for the calculation of mean age. For the purposes of consistency in this study the lowest age entered for the patient was used to perform demographic data analysis.

Descriptive analyses were performed to describe age and gender of the patient population, followed by an independent samples t-test to examine if there were any differences in age between the two genders.

The number of action items entered per patient on average was calculated, and the average number of physicians who entered action items on a single patient was computed. Several action items did not have an associated acuity rating for the patient. Given that the research was exploring if there was a relationship between action item categories listed in Table 3.1 and 3.2 and acuity level, only action items that had a documented acuity level were included in the sample. Therefore, there were two different sample sizes reported, one for descriptive statistics related to action items, and one related to inferential statistics.

Finally, a chi-squared analysis was performed to determine if there was a difference in number of action items documented within and between each acuity rating for each action item category and a relationship between the level of acuity and type of action item.

3.6.1 Data Storage

To maintain study confidentiality, data were received from the VirtualWard database manager in a password protected comma separated value (CSV) file, and were converted to a password protected Excel file. The Excel file was imported to SPSS software for data analysis. These files were stored on the study investigators' password protected computers. Only co-investigators identified on the ethics application had access to these data.

3.7 Ethics

Ethics approval from the University of British Columbia Research Ethics Board was obtained in March, 2017, and approval to conduct the study from the Providence Health Care Research Ethics Board was obtained in March, 2017. The patients whose information is documented in VirtualWard and the physicians who have entered information into VirtualWard had risks to their identification mitigated by the use of de-identified data provided from the VirtualWard database manager.

Chapter 4: Results

The purposes of this study were to: 1) classify free-text action items documented in an electronic handover tool using CCD categories; 2) understand patterns of action items in the electronic handover tool; and 3) examine the relationship between action item category and patient acuity rating. Figure 4.1 shows which data were analyzed during phase I and II. The final sample consisted of 3,444 action items.

4.1 Classification of Action Items

The limited data set that was extracted from the VirtualWard database contained 3,356 action items. After entries containing multiple action items were separated into individual events there were 3,696 action items. Of these, 252 (7.5%) had no content (n=234) or were unintelligible (n=18). Of the 3,696 action items, 3,039 (82.2%) had an associated acuity rating and 657 (17.8%) action items did not have an associated acuity rating. On average, 5.4 action items were entered per patient during the study period. The 300 action items that were categorized by both PL and SHC had an interclass correlation of 0.78 (95% Confidence Interval: 0.72-0.82) suggesting acceptable inter-rater reliability. Thus, the process of initial coding by PL and LC, provided a consistent classification process.

4.2 Frequency of action items

Table 4.1 shows the frequencies of action items for each of the CCD categories. For this step of the analysis 252 action items were excluded due to the criteria presented above. The most frequent categories of action items were those categorized as ‘results’ (n=1288, 37.4%), ‘plan of treatment' (n=690, 20%), and 'consults' (n=431, 12.5%). The least frequent action items found were 'advanced care plan' (n=21, 0.6%), and 'education' (n=9, 0.3%).

Table 4.1 Frequency of Action Item Categories

Category of Action Item	Frequency n (% of column)
Advanced Care Plan	21 (0.6)
Consults	431 (12.5)
Education	9 (0.3)
Functional Status	177 (5.1)
Medications	430 (12.5)
Other	64 (1.9)
Plan of Treatment	690 (20.0)
Problems	138 (4.0)
Results	1288 (37.4)
Social History	52 (1.5)
Vital Signs, Mental Status and Fluid Balance	144 (4.2)
Total	3,444 (100)

4.3 Description of Patients and Physicians

4.3.1 Patients

The data set included 811 patients for which there were 3,356 action items entered. Five patients were missing a documented age. Table 4.2 shows the age and sex of patients in the data set who had complete data entered. There was no significant difference in age for males and females [t(804)= -1.47, p<0.01] in the data set. There were 783 patients who had action items entered that met the inclusion criteria for phase II of this study.

Table 4.2 Characteristics of Patients in Data Set

	Male (n=505)	Female (n=301)	Overall (n=806)
Age, Mean (SD)	63.1 (16.9)	65.1 (20.4)	63.9 (18.3)

Note. Five patients excluded due to missing age

4.3.2 Physicians

The following descriptive data considered only action items that met the inclusion criteria as described earlier (i.e., items were removed if they were blank, autofilled with 'New to do', or unintelligible). The total number of physicians who entered data was 173. With the excluded action items considered there were 168 physicians/trainees who entered action items on patients. The average number of action items entered per physician was 22.35 (SD=33.67). The average number of action items entered per patient was 4.3 and the median was 3, and the minimum 1 and the maximum 84.

4.4 Relationship Between Acuity Rating and Action Item Categorization

There were a total of 3,039 action items with a documented acuity (see Table 4.3). Four hundred and five (11.76%) did not have a documented acuity rating. Most of the action items were classified as *stable acuity* (n=2,381, 78.3%). *Watch acuity* (n=581, 19.1%) was the next most common acuity rating, followed by *unstable acuity* (n=47, 1.5%), and *discharge acuity* (n=30, 1.0%). The largest proportion of action items documented for all acuities were documented in the 'results' category (n=1,125, 37%), 'plan of treatment' (n=634, 20.9%), 'consults' (n=386, 12.7%), and 'medication' (n=374, 12.3%). The smallest proportion of action items documented for all acuities were for 'social history' (n=46, 1.5%), 'advanced care plan' (n=17, 0.6%), and 'education' (n=5, 0.2%).

Results from the Chi-square analysis showed that stable acuity was significantly more likely to have action items entered than discharge, watch, or unstable acuity (X^2=133.3,(*df*=36),*p*<0.001).

Table 4.3 Frequency and Proportion of Action Items by CCD Category and Acuity Rating

	Acuity Rating								
Action Item Category	**Stable n (% of total)**	**% within Stable Acuity**	**Watch n (% of total)**	**% within Watch Acuity**	**Unstable n (% of total)**	**% within Unstable Acuity**	**Discharge n (% of total)**	**% within Discharge Acuity**	**Total n (% of column)**
Advanced Care Plan	12 (0.4)	0.9	5 (0.2)	0.5	0 (0)	0	0 (0)	0	17 (0.6)
% within category	]70.6		29.4		0		0		
Consults	322 (10.6)	13.5	59 (1.9)	10.2	4 (0.1)	8.5	1 (0)	3.3	386 (12.7)
% within category	83.4		15.3		1		0.3		
Education	3 (0.1)	0.1	1 (0)	0.2	1 (0)	2.1	0 (0)	0	5 (0.2)
% within category	60		20		20		0		
Functional Status	132 (4.3)	5.5	21 (0.7)	3.6	0 (0)	0	1(0)	3.3	154 (5.0)
% within category	85.8		13.6		0		0.6		
Medication	277 (9.1)	11.6	87 (2.9)	15	9 (0.3)	19.1	1 (0)	3.3	374 (12.3)
% within category	74.1		23.3		2.4		0.2		
Other	44 (1.4)	1.8	10 (0.3)	1.7	1 (0)	2.1	6 (0.2)	20	61 (2.0)
% within category	72.1		16.4		1.6		9.9		
Plan of Treatment	532 (17.5)	22.3	83 (2.7)	14.3	7 (0.2)	14.9	12 (0.4)	40	634 (20.9)
% within category	83.9		13.1		1.1		1.9		
Problems	80 (2.6)	3.4	34 (1.1)	5.9	0 (0)	0	1 (0)	3.3	115 (3.8)
% within category	69.9		29.6		0		0.9		
Results	851 (28.0)	35.7	244 (8.0)	42	23 (0.8)	48.9	6 (0.2)	20	1124 (37.0)
% within category	75.7		21.7		2		0.5		
Social History	40 (1.3)	1.7	6 (0.2)	1	0 (0)	0	0 (0)	0	46 (1.5)
% within category	87		13		0		0		
VS, MS, Fluid Balance	88 (2.9)	3.5	31 (1.0)	5.6	2 (0.05)	4.4	2 (0.05)	6.8	123 (4.0)
% within category	71.5		25.2		1.6		1.6		
Total	2381 (78.3)		581 (19.1)		47 (1.5)		30 (1.0)		3039 (100.0)

X^2=133.3,(*df*=36),*p*<0.001

Note: VS=Vital Signs, MS=Mental Status

4.4.1 Action Item Categories Within Acuity Ratings

Within stable acuity, the most frequently documented category was 'results,' followed by 'plan of treatment,' then 'consults.' In both watch acuity and unstable acuity the most documented category was 'results,' followed by 'medication,' then 'plan of treatment.' Within discharge acuity the most frequently documented category was 'plan of treatment,' followed by 'results,' then 'other.' Stable acuity had the most action items documented for all categories and watch acuity had the second most action items documented. Indeed, stable acuity compared to watch acuity had six times more 'plan of treatment' action items; five times more 'consults' and 'medication' action items; four times more 'functional status' action items; and three times more 'results,' 'vital signs,' 'mental status,' and 'fluid balance' action items. In stable and watch acuity every action item category had at least one action item documented. In the unstable and discharge categories four ('advanced care plan,' 'functional status,' 'problems,' and 'social history') and three ('advanced care plan,' 'education,' and 'social history') categories respectively had no action items documented.

4.4.2 Acuity Ratings Within Action Item Categories

The three most frequently documented action item categories across all acuity ratings were 'results,' 'plan of treatment,' and 'consults'. The highest proportion of all action items documented per action item category was always in stable acuity. Within stable acuity the frequency of action items documented in the action item categories ranged from 60-87%, within watch acuity 13.0-29.4%, within unstable acuity 0.0-20.0%, and within discharge acuity 0.0-9.9%. Across all action item categories watch acuity had the second highest proportion of action items documented compared to all other acuities. In unstable acuity compared to discharge acuity ‘education,’ ‘medication,’ and ‘results’ had more action items proportionally documented, while ‘other’ was less frequently documented. Both ‘advanced care plan’ and ‘social history’ had no action items documented for discharge and unstable acuity.

4.5 Summary of Results

In this study action items in the VirtualWard tool were categorized and found to align with the CCD classification. The most frequently documented action items were ‘results’, ‘consults’, and ‘plan of treatment’, and the watch acuity and stable acuity had the most action items documented compared to the unstable and the discharge acuities.

Chapter 5: Discussion

5.1 Introduction

This study examined an electronic physician handover tool. In this chapter the study results in relation to current literature will be discussed, the strengths and limitations of this study, and future practice and research recommendations. The purpose of this study was to: 1) classify free-text action items documented in an electronic handover tool using CCD categories; 2) understand patterns of action items in the electronic handover tool; and 3) examine the relationship between action item category and patient acuity rating. The results of this study showed the action items found in the VirtualWard tool were well-aligned with the CCD classification categories, and the most common CCD categories used were ‘results’, ‘consults’, and ‘plan of treatment. In addition, action items were more likely to be documented within stable acuity (78.3%) and watch acuity (19.1%). To the author’s knowledge, this is the first study that compared classification of action items documented by physicians in an electronic handover tool by acuity.

5.2 Relationship to Theoretical Model

In relation to the theoretical model of distributed cognition, this study examined how physicians used the action item documentation in VirtualWard to communicate information to other physicians. Information must be clearly communicated in order for its priority to be communicated (Hollan, Hutchins & Kirsh, 2000), and coordinating clinicians and the tools they utilize for communication can decrease communication errors. While it was beyond the scope of this study to examine the outcomes of communication between physicians, this study demonstrates that although there were 173 physicians who used the tool for 811 patients, over

3,000 actions items were classified into 11 categories, and thus were largely mappable to an existing data standard. The groupings of action items may provide a framework to be used in the VirtualWard tool action item section which may help provide clarity on action items to be done for patients. The VirtualWard tool provides a method for physicians to asynchronously perform handover, but does not take into consideration the value of synchronous communication in handover. Future research may consider examining the combination of verbal communication alongside the use of the VirtualWard tool and observing the process of handover between physicians using VirtualWard to understand the steps involved in handover.

5.3 VirtualWard Useage

While this study only focused on action items in the VirtualWard tool, it was notable that the number of events represented only a small proportion of the likely handovers in the unit. It was estimated that there would be approximately 30,000 handover events (see section 3.4). But given that there were only 3,444 events, there was limited uptake of the use of the tool. Also the number of physicians and trainees that entered action items was 173 compared to the 216 physicians and trainees expected per the guesstimate in Section 3.4. It is possible that this was due to not having the tool integrated into the electronic health record where data about the patient might be pulled into the tool as recommended by Flemming and Hubner (2013).

5.4 The Classification of Action Items and Alignment with CCD Categories

The action items in the VirtualWard tool aligned with nine of the 17 CCD categories (advanced care plans, education, functional status, medications, plan of treatment, problems, results, social history and vital signs/mental status/fluid balance.). The CCD categories that were not extracted in the VirtualWard action items dataset were: allergies, procedures, encounters, family history, immunizations, nutrition, payers section and medical equipment (Health Level International Seven, n.d.-b). It is possible that these categories were well represented in the other sections of VirtualWard, but these were not explored in this study. A future study could explore the extent to which the additional eight categories were represented.

Collins, Stein, Vawdrey, Stetson and Bakken (2011) found a higher percentage of handover content that aligned with the CCD categories (80% of content in nurse and physician electronic handovers fit the CCD categories), and 12 categories were created to categorize the remaining 20% of handover content (admission demographics, fluid balance, education, updates, pain management, orders, psychosocial concerns, anticoagulation status, prophylaxis, hospital course, past medical/surgical history, and consultations). Since Collins et al. (2011) published their findings, updates to the CCD categories have been made. For example, Collins et al. (2011) identified the need for the categories fluid balance and education, and in the 2017 CCD classification categories fluid balance was included with vital signs and mental status, and education was a newer CCD category.

Also, 11.7% of the action items were classified as 'consults' in this study, a category that is not present in the CCD despite the fact that the item was identified by Collins Stein, Vawdrey, Stetson and Bakken (2011) (consultations). The main purpose of the CCD is for handover during patient transfer between facilities, and consults are done within the facility before a patient is transferred, therefore consults might not be a relevant category for CCD purposes. However, for handover of patients during the course of an admission, consults are a frequent action item as demonstrated in this study's findings.

One potential benefit to having categorized headings for the action items section that align with the CCD classification is the potential for interoperability with other electronic health records. CCD classification is a standard that has been set by HL7, which is an international organization whose goal is to provide international standards for data in electronic health records to enable interoperability (Health Level International Seven, n.d.-a.) The possibility of interoperability of the VirtualWard tool would allow it to be interfaced with other electronic health records and handover tools when consistency in categorization of action items exist and electronic health records and handover tools have content consistency. Interoperability allows information that exists in the EHR to be integrated with and used in an electronic handover tool which would decrease manual and redundant charting (Michelson, Ho, Pelletier, Ayubi & Bourgeois, 2015; Flemming & Hubner, 2013.) Physicians have suggested that a decrease in manual entry of information and a decrease in double documentation in the chart and handover tool might help in the adoption of electronic handover tools (Li, Ali, Tang, Ghali & Stelfox, 2012.) Alignment of electronic handover tools action item categorization with an international handover categorization may also allow for data sharing and re-use when action items between different handover tools are compared.

5.4.1 Content of Action Items Documented

As discussed above, the types of action items documented in VirtualWard were largely aligned with the CCD categories. Eight of the 17 CCD categories did not appear in the VirtualWard action item classification in this study. These items may appear elsewhere in the VirtualWard tool such as in ‘Patient Summary’ and ‘Active Issues.’ The content from these sections were not analyzed in this study, but documentation of family, medical or social history, immunizations, allergies and procedures may have been documented in these sections as they pertain to an overview of a patient's information. 'Encounters' was another CCD classification that did not appear in the action item classification for this study. The purpose of the VirtualWard tool is to capture handover information for the patient's current visit and does not have the capability to track previous encounters and visits in the hospital. If this information were documented for a patient it may appear in the 'Patient Summary' section which could provide context of previous hospitalizations.

The potential for future inter-operability of VirtualWard with other electronic handover tools will require definitions of the sections in VirtualWard to guide the user in the intended use of the documentation per section. Communication between physicians might be enhanced if direction about the appropriate section information can be documented in is provided.

5.4.2 Recommendation for Action Item Categorization

In the VirtualWard tool, clinicians used free-text to document action items as recommended by Flemming and Hubner in 2013 and these free-text action items act as a list to aid physicians in keeping track of their tasks (Pryss, Mundbrod, Langer & Reichert, 2015). The Flemming and Hubner recommendation was based on their review of the literature where pick-lists were criticized as being a barrier to useage of such tools. It is possible that previously designed pick lists were not 'user-friendly', therefore designers of electronic clinical handover tools might consider using the categories from this study as a pick list for action items. More recently, Pryss, Mundbrod, Langer & Reichert (2015) recommend that a physician's task list displayed in a list format could be shared between individuals and support multi-user contributions. If this were the future design, category headings may provide increased clarity in communication of action items. Consistent use of terminology to categorize action items may mitigate elements of handover being documented in inconsistent areas of the handover tool (Keenan, Stocker, Geo-Thomas, Soparkar, Barkauskas & Lee, 2002). Use of the categorization in this study as category headings in electronic clinical handover tools may allow for better clarity for the documenting and the receiving physician by providing contextual classification via a category heading and structure within the tool (Johnson, Jeffries & Nicholls, 2012). Furthermore, if electronic clinical handover tools adopted this classification system, it would be possible to use advanced analytics without the step of classification.

However, one would need to examine usability issues, since forcing clinicians to classify on-the-fly may cause electronic handover tools to be abandoned (Michelson, Ho, Pelletier, Ayubi & Bourgeois, 2015; Flemming & Hubner, 2013). Alternately, it might be possible to develop a natural language processing algorithm to automatically classify free-text action items into the CCD categories as proposed by Stein, Vawdrey, Stetson and Bakken in 2010. Natural language processing is a field that develops techniques and computerized algorithms to turn free-text written or spoken text into data a computer can interpret (Coiera, 2015). While natural language processing requires significant effort to effectively classify data elements, Suominen et al. (2015) were able to achieve 75% classification of verbal nursing handover extracted from audio-recorded shift report. This demonstrates that natural language processing has potential as a solution to the problem of forcing clinicians to use pick list.

5.5 Relationship Between Acuity Level and Action Item Category

This study found that 78 times more action items were documented for stable acuity and 19 times more action items were documented for watch acuity than an acuity level of discharge and unstable. Hern et al. (2016) states that only 50% of clinical handovers are documented. Patient acuity may influence documentation of handover. Stable acuity may have more action items documented than watch acuity because patients are less acute and physicians may have had more time to document in the electronic handover tool rather than performing patient care. However, without additional information about physicians' thought processes when using VirtualWard this possibility cannot be confirmed.

This finding may suggest physicians using VirtualWard use means other than acuity rating to prioritize the work to be done for patients. As described in Chapter 4, there were many more action items documented for stable acuity compared to watch acuity. Specifically, action items categorized as 'plan of treatment' and 'consults' and 'medications' were more frequently documented. From a user-centered design perspective, if pre-classified categories were adopted in this tool, it may be important for these categories to be placed at the top to provide easy access to the most frequently used categories. In comparison to unstable acuity, there were 78 times more action items entered for stable acuity which may suggest action item documentation is a reflection of information about monitoring and planning a patient's care and rather than a focus on acute or critical interventions that a physician may be performing in lieu of documenting before performing. Further research would need to be carried out to explore these discrepancies.

5.6 Limitations of the Study

This study is a mixed-methods descriptive study, non-experimental design. Given this design, there are internal weaknesses to validity. The following weaknesses are discussed from a qualitative and quantitative perspective below: the concepts of conformability, transferability and dependability are used to discuss the qualitative methods in this study, and the concepts of temporal ambiguity, selection bias, maturation, and attrition are used to examine limitations to the quantitative methods.

5.6.1 Limitations to Qualitative Item Classification

Conformability is a threat to the qualitative data analysis because there is the potential for the categorization of the action items to have bias towards the data coder's interpretation. Conformability is a limitation of this study because one researcher coded 2,944 action items independently, and the researcher's supervisor coded 500 action items independently. One-thousand of these action items were coded concurrently with the researcher and researcher's supervisor sitting side by side and discussing how to classify specific items that were not clearly fitting in one category. This study could have been strengthened if two researchers had coded all 3,444 action items and achieved consensus on the classification of all action items. This was mitigated through investigator triangulation, with the research and the researcher's supervisor coding the data, and the researcher's supervising committee providing a separate coded data set that had good inter-rater reliability.

The study used a retrospective sample taken from one year of documented action items by one group of internal medicine physicians at one hospital in Western Canada, which may limit the transferability of the results (Polit & Beck, 2012). However, given that the action item categories were largely classifiable using an international standard, and that the results were similar to others' findings (e.g., Collins Stein, Vawdrey, Stetson and Bakken, 2011), the findings may be transferable to physicians who use electronic clinical handover tools for task completion and communicating tasks during handover to other physicians.

Another limitation is the dependability of the categorization. HL7 has not released definitions for the CCD categories, therefore the definitions were created by the researcher. The CCD categories that were current as of November 2017 were used in this study and if these categories were to change it may limit this study's findings. Inclusion of definitions in the HL7 standard would be a useful addition to support future studies and future interoperability.

5.6.2 Limitations to the Quantitative Analyses

Maturation may have occurred as a result of the manner in which the physicians utilized the tool at the beginning of the study versus at the end of the study. This may have caused the study data to be different at the end of the study versus the beginning due to the following possible factors: 1) physicians being more familiar with the tool which may influence the frequency of use of the tool, 2) the number of action items the physician entered when they were less familiar with the tool versus when they were more familiar with the tool, and 3) the frequency with which the physicians completed action items in real time rather than much later after the action items were completed, or not completing the action items at all. These characteristics were not examined in this study.

Selection bias may have occurred in this study depending on if the type of patients the physicians chose to enter action items on changed over time, for example if physicians chose to enter less acute patients over time into the tool. Mitigation of this risk would be difficult in a retrospective design of this study and would be better mitigated if this study was prospectively designed and the ability to enforce consistency in the usage of the tool by physicians was possible.

Attrition was another threat that arose from this study, as over the year period of the study physicians that used the tool at the beginning may no longer be covering the medical ward and therefore would not be inputting data into the tool. This posed a risk for inconsistent use of the tool by different individuals over the study's year timeframe.

The above-mentioned biases were mitigated by the sample size of 3,356 action items and by collecting data from a period spanning one calendar year to enhance the ability for statistical conclusion validity (Polit & Beck, 2012).

5.7 Relevance to Nursing

The findings from this study can support the design of electronic handover tools which are used by professionals other than physicians, including nurses. Locally, there are no known electronic handover tools for nurses in use, and the findings from this study may help to support the potential to adapt the tool for use by nurses. Also, the categorization of action items can provide a means to compare the types of actions items physicians versus nurses are communicating during handover. Nursing is a profession that collaborates with clients to "deliver direct health-care services, coordinate care and support clients in managing their own health" (Canadian Nurses Association, 2015). Johnson, Jeffries and Nicholls (2012) found the structure of handover must be congruent with the practice context needs. Nursing's holistic client focused care may require handover tools used by nursing to be designed encompassing categories such as 'education' and 'social history' that are important in nursing practice. This study found physicians captured this information infrequently ('education' was captured 0.2% and 'social history' captured 1.5% of the total action items). Implementation of the tool for use in nursing handover would require a nursing lens review to determine if the tool suits nursing handover needs, or possible changes to the tools to encompass content important to nursing would need to occur.

5.8 Recommendations

5.8.1 Recommendations for Nursing Practice

Research has shown that electronic clinical handover tools exist in many formats with varying structures (Flemming & Hubner, 2103). Multiple clinical handover tools are used in practice today (Starmer et al., 2012) and organizations should ensure the electronic clinical handover tool used supports clinicians' workflow for successful adoption (Abraham et al., 2016; Flemming & Hubner, 2013; Van Eaton et al., 2005.)

Health care organizations must provide support to practitioners in implementation and education of an electronic clinical handover tool when introduced in clinical settings. Education about the clinical tool and its intended use should be provided for physicians, nurses and clinicians using the tool. Education, in conjunction with a structured handover tool, was identified as a component required in the success of a handover tool reducing adverse events (Starmer et al., 2014). The importance of handover education is also supported by the Resident Doctors of Canada (Resident Doctors of Canada, 2016), and in the United States, the Accreditation Council for Graduate Medical Education who incorporate formal education about handover in the medical curriculum (Starmer et al., 2014). Education on intention of use an electronic clinical handover tool may provide consistency in its use by physicians and clinicians. This consistency would help clinicians document action items in the appropriate category, which could increase clarity of the context behind what the clinician is communicating about the patient.

A decrease in ambiguity of action required from an action item may increase communication between physicians if clarity is added with categorization headings.

5.8.2 Recommendations for Nursing and Healthcare Policy

Future recommendations for nursing and healthcare policy may include documented handover as part of the legal patient documentation. The presence of an electronic handover tool allows for an electronic permanency of documented handover. Handover when done on paper is often discarded, and approximately 50% of handover is documented in a temporary (non-legal) form (Hern et al., 2016). An electronic handover tool would allow an accessible and legible manner for the content of handover to be examined by healthcare leaders to understand what information is being communicated during handover. In the instance of an adverse event, an electronic handover tool could be examined for the content to understand if there was a possible cause of the event related to handover. The examination of handover as a possible contributor to an adverse event would need to be examined in the context of the event and with the consideration of any miscommunication (e.g. a misunderstanding of information between clinicians or the presence of distractions increasing a clinician's cognitive load such as a busy patient workload). An electronic handover that is part of the patient's chart could also provide documented evidence of what information was provided during handover.

Another policy recommendation might include recommending a specific handover structure or tool to be used within the healthcare organization. If a healthcare organization has an electronic health record in place it would be recommended that an interoperable electronic handover tool be used to minimize double charting that affects physician adoption of an electronic handover tool (Hern et al., 2016.) Though policy cannot dictate all aspects of how handover is done, policy could recommend specifics be documented in the electronic handover tool. Certain recommendations for what should be documented in the electronic health record could be the following: documenting when the patient's acuity status changes, and resolving action items when the clinical action is complete to provide communication clarity to the healthcare team.

5.8.3 Recommendations for Nursing and Healthcare Future Research

The VirtualWard is an electronic handover tool that utilizes a structured format and includes sections commonly found in other handover tools such as patient demographics, history, and 'to do' lists (Flemming & Hubner, 2013; Johnson, Jeffries & Nicholls, 2012.) Literature has demonstrated structure in handover can reduce adverse events (Starmer et al., 2014,) and future research may focus on examining if the structure in the VirtualWard tool decreases adverse events. Future research might also examine why there is a discrepancy between number of documented action items in handover in comparison to the number of handovers that were likely performed. Research to lend insight into this discrepancy can provide a better understanding to potential barriers to adoption of electronic handover tools. Another potential for future research would be the use of natural language processing to categorize free-text action items documented in electronic handover tools. This would allow large amounts of data to processed versus manual processing by a human. Natural language processing would need to be developed to recognize patterns of language used in free-text action items in order to use algorithms to categorize them.

5.9 Summary

This study classified action items in the VirtualWard tool and found the action items aligned with the CCD classification. Action items were most frequently documented in the ‘results’, ‘consults’ and ‘plan of treatment’ categories, and watch acuity and stable acuity had actions items more frequently documented. Additions of categorized headings to the action item section of VirtualWard may improve the clarity of communication between physicians using the tool, but factors that contribute to communication complexity, such as distractions and misinterpretations, must also be considered.

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