

Critical factors in the information management process: the analysis of hospital-based patient safety incident reports

Virpi Jylhä, MSc¹, David W. Bates, MD², Kaija Saranto, PhD¹

¹ Department of Health and Social Management, University of Eastern Finland, Finland; ² Partners HealthCare Information Systems, Division of Clinical and Quality Analysis; The Division of General Medicine and Primary Care, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, and Harvard School of Public Health, Boston, MA, USA

Virpi Jylhä, University of Eastern Finland, Department of Health and Social Management. P.O. Box 1627, FI-70211 Kuopio, FINLAND. Email: virpi.jylha@hotus.fi

Abstract

The purpose of this study is to describe the nature of patient safety incidents relating to information management and to identify critical factors for a safe information management process in a university hospital. A total of 813 information management incidents in hospital-based adverse event reports were analyzed using directed content analysis. Descriptive statistics and cross tabulations were used to quantify the results. The results of this study showed that the majority of incidents occurred during the information distribution phase. The most frequent incidents fell into the category of written information transfer and communication; furthermore, many of these incidents concerned medication data. There was a high amount of inaccurate data and omissions in the different phases of the information management process. Information organization and storage, information distribution, and information use phases are critical in terms of patient safety, and a high proportion of the problems in this area are potentially preventable. It is thus essential to develop more effective strategies to ensure safe information management. The data from this study also suggest that while incident reports can help to identify breakdowns in the information management process, the quality of reporting needs to be improved.

Keywords: patient safety, information management, medical errors, medication errors, communication, hospital information systems

Introduction

Health professionals need clinical information in different forms at all phases of care in order to make proper decisions related to patient care [1]. The right information at the right place and the right time is a key principle in health information management. The information management during the care process includes several phases in which patient data are collected, recorded, synthesized, and shared [2]. In this study, the definition of the information management process in an organization is adapted from Choo (2002), that is, a continuous cycle of six closely related activities: the identification of information needs, information acquisition, information organization and storage, development of information products and services, information distribution, and information use [3]. These phases are repeated during the care process multiple times.

In clinical decision making, information needs arise from the patient status and problems in a care situation in which the health professional recognizes information deficits when caring for the patient. In addition to clinical patient data, clinical decision making involves combining different types of information, including research evidence, the knowledge arising from one's clinical expertise, and patient preferences [4]. In this study, we focus on the management of clinical data, including medication data, which is needed information to make proper clinical decisions and solve health problems. Clinical data include all data related to the patient episode, such as medication data, allergy data, referral or invitation to the procedure/care, summary of care for the discharge, and patient-related guidelines or care instructions.

Information needs lead to information seeking in order to assess the patient's situation by, for example, looking for his/her medical history in the electronic patient record (EPR) or laboratory results. Once acquired, the information must be organized and stored systematically—for example, in the EPR or other records—in order to facilitate information distribution and use. In other words, the stored data should be reused and available to health professionals when they need it [3, 5]. As a result, stored information should be transformed into a

usable form as information products and services, which formulate part of the knowledge base of the organization and assist health professionals to make better decisions in patient care [3]. In addition, part of the information is preserved in the memories of individuals as tacit knowledge gained through experience or transmitted via training [6]. Information distribution enables the use of information in patient care during transitions of care and in handovers during and between shifts, thereby leading to the appropriate clinical decision making and patient care [3, 7].

Past studies have concluded that information management incidents are one of the most common contributing factors for adverse events [8, 9]. Hohenstein et al. (2016) analyzed adverse event reports and found that 27.5% of all reported incidents included communication deficits [10]. In Finland, the HaiPro reporting system is widely used in hospitals, and a study by Ruuhilehto et al. (2011), analyzed 64,405 incident reports from 36 user organizations. The results showed that the most common incident type was medication management (51%) followed by accidents (13%), and information management (12%) [11]. However, the actual number of information management incidents was probably higher because in the classification system used in the reporting, the sub-category of medication documentation overlaps with the main category of information management [12]. Härkänen et al. (2013) analyzed medication-related incident reports and found that errors occurring in the documentation phase of medication management were frequent (25%) [13].

Inter-professional communication and information transfer seem to be sensitive to errors and misunderstandings [7, 9, 14-15]. Accurately documented and transferred clinical information at discharge or at transfers of the patient inside or outside the hospital is essential to secure the continuum of care and patient safety [15-17]. However, errors in documentation are commonly associated with medications, especially prescribing [11, 13, 18-20], but also across the perioperative pathway [21]. Medication lists include inaccuracies and are incomplete in every phase of care regardless of whether electronic documentation is used [22-25]. Callen et al. (2010) analyzed the accuracy of medication

documentation in hospital discharge summaries and identified an error rate of 12% in the handwritten and 13% in the electronic summaries [23]. A literature review conducted by Lewis et al. (2009) found a median error rate of 7% for medication orders; the most common error type was an incorrect dosage [26]. Failures in the information transfer or in the documentation of lead to unintended patient outcomes if inaccurate or incorrect patient information is used in the clinical decision making [9, 16, 21]. Further, data integrity is thus a prerequisite for patient safety [27]. For example, copying and pasting data from one system to another is a threat to data integrity and duplicates the work for health professionals [28]. If heterogeneous clinical data exist in patient records in various documents and multiple information systems are used while documenting patient information, health care professionals may have to make several entries in order to fully document, for example, patients' medication information [19, 28, 29]. According to previous studies, missing clinical information in clinical decision making is a well-known problem in the health care practice and has been found to be a contributory factor in adverse events [1, 30]. Medication errors are associated with lack of information, generally because information was not available at the time it was needed [19]. Thus, the availability of information also plays an important role in patient safety.

The analysis of health information technology (HIT) errors made by Magrabi et al. (2012, 2013) suggested a classification for HIT problems; information output errors, software functionality, and machine-related problems were typical types of errors [31, 32]. The results of the study conducted in Finland, using adverse event reports, confirmed Magrabi's results and widened the categories [33]. However, information management is not solely a technological discipline; rather, it is a complex process where data is processed as knowledge. Our study focuses on the steering and organizing of information management processes, which represent the interaction of action and data—two basic entities in the research paradigm of health and human services informatics [34]. It is important to understand both how information is processed and the possible breakdowns in the information management process.

More information is thus needed to understand the key elements of the information management process to secure patient safety. In this study, we describe errors occurring in the information management process by analyzing the content of adverse events and near-miss incident reports. This study has two objectives: to describe the nature of the incidents and to identify critical factors for a safe information management process.

Materials and methods

Setting

The study hospital was a university hospital (771 beds) in Finland that includes all of the main specialties. The hospital has implemented an electronic incident reporting system, known as HaiPro, to increase the documentation of adverse events and near-miss situations in order to utilize this data in quality improvements [35]. The system, implemented nationwide, enables all health care professionals to report adverse events and near misses into the system anonymously. The features of the HaiPro system comply with the following factors for the successful implementation of a reporting system [36]. First, it is built on a non-punitive and confidential environment, which is a prerequisite for the use of the reporting system. Second, the system is independent from authority and mandatory reporting systems. Third, according to the reporting process, users receive timely feedback for their reports after clinical experts have analyzed them. Finally, actions taken are targeted to system improvements.

An incident report include the reporter's unit, the unit where the incident occurred, the profession of the reporter, the time of occurrence, the nature of the event, and the event type. In addition, a reporter can enter more specific incident descriptions as narrative text into the system, including description of the incident, consequences for the patient and the organization, and the reporter's opinion regarding how this kind of incident could be prevented. When the report is entered into the system, a report handler, which is usually a manager, reviews the incident report and assigns a level of impact for the patient and the hospital using pre-defined categories; the handler includes con-

tributing factors based on the classification used in the reporting system [35] and describes preventive actions for the event report.

Data collection

Prior to data collection, research permission for this study was obtained from the organization as a database holder, but according to organizational policy, the approval of the ethics committee was not needed. The basic principles of research ethics were considered and strictly followed during the study and the data were stored in a secure place. Even though the data were entered anonymously, it might be possible to recognize private matters. For that reason, the researchers were committed to confidentiality concerning all the register data. The data consisted of near misses and adverse events incident reports (n = 3,075) that occurred from January 2008 through the end of December 2009. All hospital specialties and health professionals were included in the study. In the reporting system, nationally uniform classification is used [35]. The types of adverse

events and near misses are classified using 14 main categories with several sub-categories. In this study, all reports documented under the main category “information management” (all sub-categories) and the “medication management” sub-categories “prescribing and transcribing” and “documentation” were included. Figure 1 presents the data selection process for this study. The main category of “medication management” was divided into eight sub-categories in accordance with medication management process. The inclusion criteria were based on the preliminary review of the study data, which showed that documentation-related events during the medication management process are reported mainly under the medication management category or the information management category. Earlier studies have confirmed that the medication management process is prone to errors and that errors related to information management occur especially in the prescribing and transcribing phase [19, 23]. Consequently, the medication management sub-categories prescribing and transcribing and documentation were selected in this study and other medication management sub-categories were excluded.

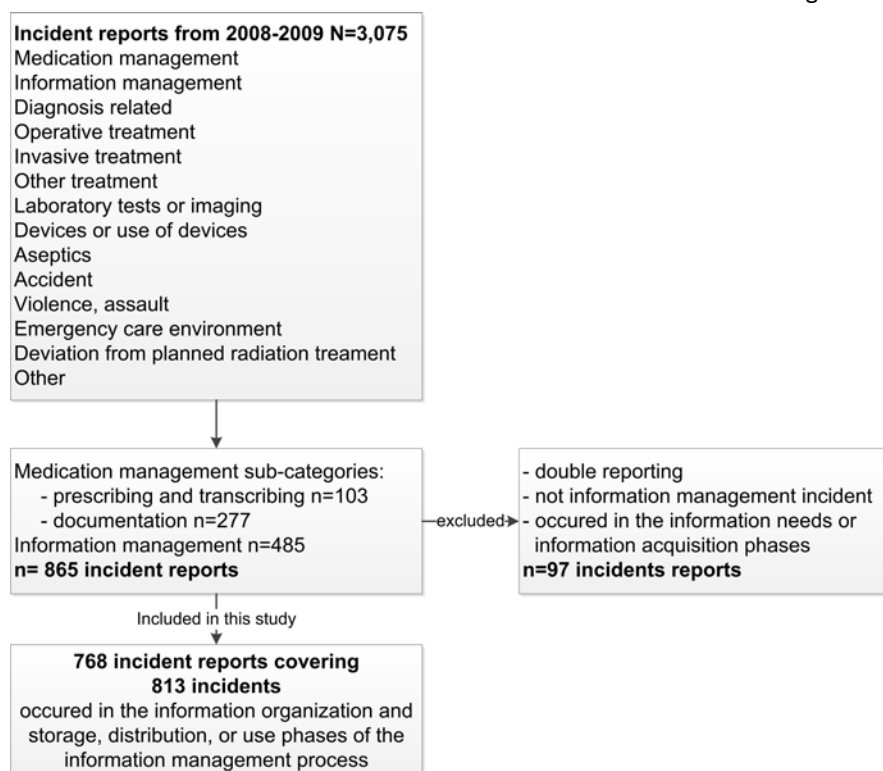


Figure 1. The flow chart for data selection.

Data analysis

All included incident reports (n=865) were printed and the data were entered into a data extraction sheet in Microsoft Excel 2007. We categorized the incidents into the following four main categories: 1) written information transfer and communication, 2) verbal information transfer and communication, 3) patient-specific or clinical practice guidelines, and 4) arrangement of care. Each main category was classified in five sub-categories, which are presented in Table 1. The main category of “written information transfer and communication” included electronic data as well as hardcopy and written notes.

We created following new variables: “information management,” which included five categories based on the information management process model [3]; “information type,” which included seven categories; and

“care record,” which included six categories. The definitions of these variables are presented in Table 1. The categorization was based on the original classification used in the reporting system and the results of earlier research on preventable adverse events in health care [19]. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) patient safety event taxonomy was utilized in the development of the categories [37]. Directed content analysis was used as a method to categorize the incidents with predetermined codes [38]. New categories/sub-categories were created if the data could not be coded in existing categories. One researcher (VJ) analyzed the content of the reports and categorized the study variables. Similar events were systematically analyzed and grouped into the same categories defined in the beginning of the study. Unclear cases were solved by discussion with the co-author (KS).

Table 1. New research variables and their definitions.

VARIABLE	DEFINITION
Information Management Process [3]	
<i>Information needs</i>	Identifying the problem and the information needed
<i>Information acquisition</i>	Collecting needed information using different kind of means such as patient examination, interviewing and reviewing patient charts
<i>information organization and storage</i>	Saving and documenting different kind of data relating to patient care
<i>Information distribution</i>	Distribution of written or verbal patient data/instructions from place to another
<i>Information use</i>	Use of patient data/instructions in the clinical decision-making in care situations
Subcategory of Incident Type	
<i>Inaccurate data</i>	The data was not complete or it was erroneous
<i>Inaccurate record</i>	The data were stored in wrong document/order record
<i>Misunderstanding</i>	The communication was not received as it was intended
<i>Omission</i>	Something that has not been included or done [39]
<i>Technical</i>	The event were related to the use of technology
Information Type	
<i>Medication data</i>	All data related to medication
<i>Clinical data</i>	Non-medication patient data
<i>Referral</i>	The document written by a doctor to send patient to a health professional or to a place offering specific treatment/examination
<i>Admission letter</i>	An invitation letter of the appointment to the person/location where the patient was referred
<i>Guidelines</i>	Advice given by a senior health professional to a colleague, or a general clinical practice guideline or instructions used in the organization
<i>Discharge data/letter</i>	Patient data collected before discharge

<i>Allergy/risk data</i>	Any allergy or risk data needed to know
Care Record	
<i>Medication card</i>	Usually a paper card where patient's prescriptions are summarized; sometimes printed out on the EPR; mainly used when medications are dispensed
<i>Electronic patient records (EPRs)</i>	Patient records in an electronic information system; not a medication list
<i>Medication list</i>	Part of EPR; lists patient's medications
<i>Prescription</i>	Document on which a doctor prescribes a particular medicine; mainly electronic
<i>Care summary</i>	Summaries the patient data of the care episode; includes an anesthesia form; might be on paper or in an electronic form
<i>Other</i>	Other types of records/documents

Before statistical analysis, the data were cleaned to check for outliers and missing values. In the case of a missing value, the report was reread to gather missed information. In addition, possible inconsistencies in the data were checked by comparing variable values. Descriptive statistics and cross tabulation were used to describe the incidents during the information management process. The frequencies are reported as quantities and percentages. All statistical analyses were undertaken with IBM SPSS Statistics version 21.0 (IBM Corporation, USA).

The characteristics of reported incidents and adverse event reporting choices of health professionals are described in the previous publication [12].

Results

A total of 865 incident reports meeting the inclusion criteria were submitted in the reporting system during the study period. During the analysis, 97 reports were excluded due to double reporting, the content of the report did not relate to information management or because incident occurred in the information needs or acquisition phases of the information management process. More than one incident was identified in 25 reports, and these reports were analyzed as separate

incidents in this study. As a result, a total of 768 reports covering 813 incidents that occurred in the information organization and storage, distribution, or use phases of the information management process are included in this paper. In all, 49% of the incidents were reported in 2008 and 51% in 2009. A total of 45% were near-miss situations and 55% were adverse events impacting the patient. Of these, 28% caused at least mild harm to the patient, and 5% caused harm that required treatment or resulted in serious injury or death.

Figure 2 illustrates the frequencies of information management incidents and their classified sub-categories using the process model of information management. Most of the reported information management incidents occurred during the information distribution ($n = 437$) phase, which included the distribution of verbal and written data as well as information distributed via guidelines and instructions. The information organization and storage phase was also critical; a total of 299 incidents occurred when patient data were stored, for example, in EPRs or other documents. Failures in information use ($n = 77$) included care arrangement and patient data issues. Of the total number of incidents ($n = 824$), written information transfer and communication ($n = 679$, 84%) was the most frequently used main category followed by verbal information transfer and communication ($n = 58$, 7%).

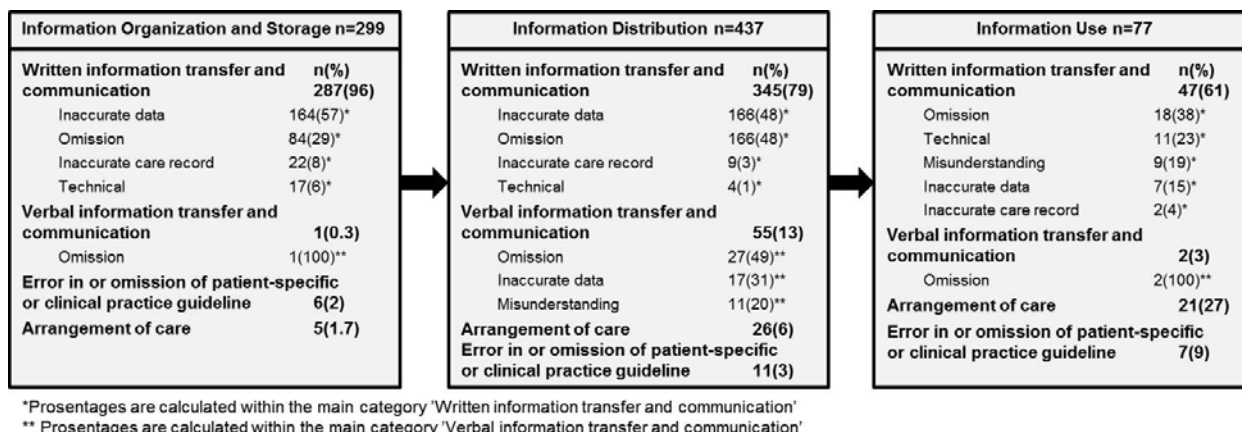


Figure 2. Frequencies of information management incidents classified using the modified information process model [3].

As presented in Figure 2, the most significant main category in the information organization and storage phase was written information transfer and communication (n = 287, 96%). Of this category's sub-categories, the two most frequent were inaccurate data (57%) and omission of information storage (29%). Inaccurate data were usually a consequence of documentation or copying of patient data, but cases of missing patient data were always the result of omissions to document the necessary data. In addition, we identified 22 cases

where patient data were documented in the wrong record, for example, in the EPR. Within this main category, technical difficulties seemed to be a minor problem; data input was rendered impossible in only 6% of the cases. Table 2 shows the characteristics of incidents that occurred in the information management process. In most of the incidents, the data type was medication data (71%) or clinical data (18%). Data were typically stored in medication lists (32%), EPRs (26%), or prescriptions (26%).

Table 2. Characteristics of incidents in the information management process.

	ALL n (%)	Organization and storage	Distribution	Use
Information Type	811 (100)	299 (100)	436 (100)	76 (100)
Medication data	510 (63)	212 (71)	273 (63)	25 (33)
Clinical data (non-medication)	142 (18)	54 (18)	68 (16)	20 (26)
Referral/Admission letter	105 (13)	24 (7)	58 (13)	23 (30)
Instructions/guidelines	19 (2)	1 (0)	12 (3)	6 (8)
Discharge data	19 (2)	2 (1)	17 (4)	0 (0)
Allergy/risk data	16 (2)	6 (2)	8 (2)	2 (3)
Care Record	650 (100)	275 (100)	321 (100)	54 (100)
Medication card (for dispensing)	180 (28)	15 (6)	161 (50)	4 (7)
Electronic patient record	170 (26)	72 (26)	67 (21)	31 (57)
Medication list	120 (18)	88 (32)	24 (8)	8 (15)
Prescription	83 (13)	72 (26)	4 (1)	7 (13)
Care summary	65 (10)	18 (7)	46 (14)	1 (2)
Other	32 (5)	10 (4)	19 (5)	3 (6)

At the information distribution phase, the majority of failures within the main category of written information transfer and communication (79%) were related to the distribution of inaccurate data (48%) and omission in transferring the data needed (48%) (Figure 2). The second most common failure type was verbal information transfer and communication; within this category, the sub-categories of omission (49%) and inaccurate data (31%) were the most common. Within this phase, we also identified 17 cases where one patient's data were sent to another patient. As Table 2 delineates, medication data (63%) was the most common data type at this phase followed by clinical data (16%) and referral/admission letter (13%). Typically, the data were stored in medication cards (50%), EPRs (21%), or care summary (14%).

The total number of incident reports ($n = 77$) for information use was lower than for the two other phases of the process (Figure 2). The most common main category was written information transfer and communication (61%) followed by arrangements of patient's care (27%). Written information issues included omissions in using data (38%), technical errors (23%), and misunderstandings (19%). At the information use phase, the most common data types in incident reports were medication data (33%), referral/admission letters (30%), or clinical data (26%). The majority of the data was stored in EPRs (57%).

Discussion

In this study, we analyzed incident reports related to information management and discovered that failures were common in the information storage and information distribution phases. The error types in different phases of the information management process were mainly the same, but their occurrence differed between phases. The amount of inaccurate data and omissions in the transfer of information and communication was remarkably high in all phases. If errors in entering information and omissions are not noticed before clinical decision-making, an error can affect the patient with serious or even fatal consequences [31]. In our data, 5% of information management incidents harmed a patient

seriously [12]; furthermore, all of the incidents were preventable types of adverse events and near-miss situations.

We aimed to identify critical factors in the information management process [3]. The results of this study confirm earlier research: that information transfer [15-17] and the accuracy of documentation need improvements [22-24, 26]. Our study found that the most important factors in the information organization and storage phase are the accuracy of data and documentation of the necessary patient data in the record. Although standardized data entries have been implemented, inconsistencies in drug dosages were shown to be prevalent, other factors need to be improved in the workflow [18].

Data accuracy and omissions were also critical factors to deliver safe patient care in the information distribution phase. Furthermore, omissions of transfer of patient data occurred regularly. In the information use phase, failure to review patient data was frequent, but misunderstandings in communications also occurred. Although electronic patient records were in use, only a small proportion of events were technological problems in this study. These cases mostly occurred during the information organization and storage and information use phases where data search or data input was not possible. Magrabi et al. (2012) have studied health information technology (HIT) safety problems, and they identified that most of the HIT problems were related to machines; however, data input problems were also widely present in their data [31]. In Finland, Palojoki et al. (2016) studied HIT-related incidents using HaiPro incident reports. They concluded that human-computer interaction problems were associated with most HIT-related incidents (73%), and machine-related problems were in minority (8%). In our study, the main category, devices or use of devices, were excluded as our scope was the information management process instead of technology induced errors, and this might have affected this finding.

Particularly in the information organization and storage and information distribution phase, the most common data type was medication data. This confirms the re-

sults of Ruuhilehto et al. (2011) where over half of incidents were associated with the medication process [11]. In this study, the medication data appeared to be documented and transferred manually in multiple records. Despite the introduction of electronic patient records, in many systems, paper persists and thus manually written and stored patient data are also used. This can lead to duplicate documentation and unnecessary copying when patient data are transferred from one record to another, and inconsistencies are frequent. The results of this study supported the results of previous studies that documentation in multiple records compromise patient safety in the information management process [21, 28, 29].

Other evaluations have been conducted in the previous study [12], but in this report we have focused on the information management process. This had limitations, as information management practices are not easy to identify as reportable events, which is precisely the reason why they are underestimated in the adverse event report data. We selected all adverse event reports categorized under the main category, information management, and the medication management sub-categories (prescribing and transcribing and documentation). We supposed that the majority of information management incidents were reported under those categories, but it is possible that we did not capture all of them. The study data were heterogeneous and the descriptions of the situation were very often narrow. This limited our options with respect to evaluation, especially in terms of developing a deeper understanding of each incident. This was also the case when re-analyzing the type and characteristics of incidents (Figure 2 and Table 1). In order to improve the reliability of the data, the researcher (VJ) systematically classified similar cases into the same categories by creating rules for cases that occurred repeatedly in the data. Other limitations include that the data are from only one institution in one country, and thus the results might not be representative of other institutions or nations, especially in institutions in which less advanced information technology is in place.

The use of adverse event reports as data limits the generalization of the results to other hospitals because

the types of reporting systems and organizational cultures have an effect on the incident reporting [40-43]. Adverse events and near misses are more likely to be reported if they cause harm for the patient and the incidence type has an influence on the likelihood of reporting [40, 41]. It is possible, that unbalanced reporting creates a false impression of the incidence of adverse events and the types of most common events leading to the incorrect prioritization of preventive activities [44]. However, none of the methods used to detect incidents capture all adverse events. For example, events found in patient charts do not overlap with those found using other methods such as a review of patient complaints or event reporting [43]. Further, it seems that the collected adverse event data captures a different spectrum of adverse events than is known to occur in health care [45]. Regardless of these concerns that voluntary incidence reporting in health care has faced about its accuracy and issues of underreporting, incident reports represent one valuable source of data about the factors and circumstances related to adverse events, and that they can enhance patient safety through learning from the failures that occurred [11, 20, 36, 42, 43].

Our study showed that incident reports can be used to identify risky information management practices, but it is important to note that they do not offer a complete picture of all the kinds of failures that occur [36, 42, 43]. However, well-documented incident reports represent a key building block for developing strong organizational practices for safety improvement. It requires that the quality of the reports must be evaluated and monitored and the capture of information management incidents should also be improved. The classification used in the reporting system needs further development because the sub-category of medication documentation overlaps with the main category of information management. In incident reports, both the quantitative portion and associated narratives include information that is needed to make these reports actionable for improving safety. This is a challenge for health care organizations; the best ways to produce readable and accurate incident reports and to continuously improve their quality require further research.

This study emphasized the information management viewpoint; our findings underscore the points that the organization, storage, distribution, and use of information are all critical in terms of patient safety, and that a high proportion of the problems in this area is potentially preventable. However, doing so requires re-designing the workflow and systems to prevent errors. The development of information systems should follow the workflow, support safe information management practices, support safe documentation practices and enable the re-use of data after it is entered the first time [28]. In addition to technology, work practices in the organization are the key in preventing patient safety incidents, and they should be clearly defined. Therefore, there should be discussion regarding whether the current practices of the organization actually create opportunities for errors. It is important to understand how health professionals process clinical information in the care process. Organizational guidance is needed to guarantee accurate communication at different phases of care [28], but the system approach focusing on the entire process needs to be employed. It is essential to develop effective educational interventions for ensuring competence for safe information management.

Evidence-based information management practices are needed in order to utilize effective tools in managing clinical information. Improvements at the information distribution phase may be achieved using checklists when a patient is transferred from one unit to another or discharged [46]. Misunderstandings in communications could be prevented by using exact terms and minimizing the use of abbreviations [47]. Technological tools such as automated alerts in electronic patient record system and automated documentation using RFID might improve information storage and documentation [48]. Moreover, electronic patient records should be available at the point of care when needed and multiple documentation of the same information has to be avoided.

Acknowledgments

We wish to thank study hospital for providing the study data and assistance in data retrieval. This study was

supported by a grant from the National Post Graduate School in Social and Health Policy, Management and Economics (University of Eastern Finland).

Conflicts of Interests

The authors declare that there are no conflicts of interest.

References

- [1] Smith PC, Araya-Guerra R, Bublitz C, Parnes B, Dickinson LM, Van Vorst R, et al. Missing Clinical Information During Primary Care Visits. *J Am Med Inform Assoc* 2005;293(5):565–571.
- [2] MeSH. Health Information Management. Available at: <http://www.ncbi.nlm.nih.gov/mesh/68063025>. Accessed 12 Aug 2016.
- [3] Choo CW. Information Management for the Intelligent organization. The Art of Scanning the Environment. Third ed. Medford, New Jersey: Information Today, Inc.; 2002.
- [4] Thompson C, Cullum N, McCaughan D, Sheldon T, Raynor P. Nurses, information use, and clinical decision making – the real world potential for evidence-based decisions in nursing. *Evid Based Nurs* 2004;7(3):68–72.
- [5] Rudin RS, Bates DW. Let the left hand know what the right is doing: a vision for care coordination and electronic health records. *J Am Med Inform Assoc* 2014;21(1):13–16.
- [6] Kothari A, Rudman D, Dobbins M, Rouse M, Sibbald S, Edwards N. The use of tacit and explicit knowledge in public health: a qualitative study. *Implement Sci* 2012;7(1):20.
- [7] Nagpal K, Vats A, Lamb B, Ashrafian H, Sevdalis N, Vincent C, et al. Information Transfer and Communication in Surgery: A Systematic Review. *Ann Surg* 2010;252(2):225–239.
- [8] Milch CE, Salem DN, Pauker SG, Lundquist TG, Kumar S, Chen J. Voluntary Electronic Reporting of Medi-

- cal Errors and Adverse Events. *J Gen Intern Med* 2006;21(2):165–170.
- [9] Hohenstein C, Fleischmann T, Rupp P, Hempel D, Wilk S, Winning J. German critical incident reporting system database of prehospital emergency medicine: Analysis of reported communication and medication errors between 2005–2015. *World J Emerg Med* 2016;7(2):90–96.
- [10] Carter AW, Mossialos E, Darzi A. A national incident reporting and learning system in England and Wales, but at what cost? *Expert Rev Pharmacoecon Outcomes Res* 2015;3:1–4.
- [11] Ruuhilehto K, Kaila M, Keistinen T, Kinnunen M, Vuorenkoski L, Wallenius J. HaiPro--what was learned from patient safety incidents in Finnish health care units in 2007 to 2009? *Duodecim* 2011;127(10):1033–1040.
- [12] Jylhä V, Bates DW, Saranto K. Adverse events and near misses relating to information management in a hospital. *HIM J* 2016 Apr 14. [Epub ahead of print] doi:10.1177/1833358316641551
- [13] Härkänen M, Turunen H, Saano S, Vehviläinen-Julkunen K. Medication errors: what hospital reports reveal about staff views. *Nurse Manag UK* 2013;19(10):32–37.
- [14] Rabøl LI, Andersen ML, Østergaard D, Bjørn B, Lilja B, Mogensen T. Descriptions of verbal communication errors between staff. An analysis of 84 root cause analysis-reports from Danish hospitals. *BMJ Qual Saf* 2011;20(3):268–274.
- [15] Ong MS, Coiera E. A systematic review of failures in handoff communication during intrahospital transfers. *Jt Comm J Qual Patient Saf* 2011;37(6):274–284.
- [16] Kripalani S, LeFevre F, Phillips CO, Williams MV, Basaviah P, Baker DW. Deficits in Communication and Information Transfer Between Hospital-Based and Primary Care Physicians. *J Am Med Inform Assoc* 2007;297(8):831–841.
- [17] Vermeir P, Vandijck D, Degroote S, Peleman R, Verhaeghe R, Mortier E, et al. Communication in healthcare: a narrative review of the literature and practical recommendations. *Int J Clin Pract* 2015;69(11):1257–1267.
- [18] Singh H, Mani S, Espadas D, Petersen N, Franklin V, Petersen LA. Prescription errors and outcomes related to inconsistent information transmitted through computerized order entry: a prospective study. *Arch Intern Med* 2009;169(10):982–989.
- [19] Jylhä V, Saranto K, Bates DW. Preventable adverse drug events and their causes and contributing factors: the analysis of register data. *Int J Qual Health Care* 2011;23(2):187–197.
- [20] Shaw KN, Lillis KA, Ruddy RM, Mahajan PV, Lichtenstein R, Olsen CS, et al. Reported medication events in a paediatric emergency research network: sharing to improve patient safety. *Emerg Med J* 2013;30(10):815–819.
- [21] Braaf S, Manias E, Riley R. The role of documents and documentation in communication failure across the perioperative pathway. A literature review. *Int J Nurs Stud* 2011;48(8):1024–1038.
- [22] Staroselsky M, Volk LA, Tsurikova R, Newmark LP, Lippincott M, Litvak I, et al. An effort to improve electronic health record medication list accuracy between visits: Patients' and physicians' response. *Int J Med Inform* 2008;77(3):153–160.
- [23] Callen J, McIntosh J, Li J. Accuracy of medication documentation in hospital discharge summaries: A retrospective analysis of medication transcription errors in manual and electronic discharge summaries. *Int J Med Inform* 2010;79(1):58–64.
- [24] Avidan A, Dotan K, Weissman C, Cohen MJ, Levin PD. Accuracy of manual entry of drug administration data into an anesthesia information management system. *Can J Anaesth* 2014;61(11):979–985.
- [25] Edwards ST, Neri PM, Volk LA, Schiff GD, Bates DW. Association of note quality and quality of care: a cross-sectional study. *BMJ Qual Saf* 2014;23(5):406–413.
- [26] Lewis PI, Dornan T, Taylor D, Tully MP, Wass V, Ashcroft DM. Prevalence, Incidence and Nature of Prescribing Errors in Hospital Inpatients. *Drug Saf* 2009;32(5):379–389.

- [27] Kaelber DC, Bates DW. Health information exchange and patient safety. *J Biomed Inform* 2007;40(6 Suppl):S40–S45.
- [28] Bowman S. Impact of electronic health record systems on information integrity: quality and safety implications. *Perspect Health Inf Manag* 2013;10:1c.
- [29] Saranto K, Ensio A, Jokinen T. Patient medication—How is it documented? *Stud Health Technol Inform* 2006;122:738–741.
- [30] Burnett S, Deelchand V, Dean Franklin B, Moorthy K, Vincent C. Missing Clinical Information in NHS hospital outpatient clinics: prevalence, causes and effects on patient care. *BMC Health Serv Res* 2011;11(1):114.
- [31] Magrabi F, Ong M, Runciman W, Coiera E. Using FDA reports to inform a classification for health information technology safety problems. *J Am Med Inform Assoc* 2012;19(1):45–53.
- [32] Magrabi F, Aarts J, Nohr C, Baker M, Harrison S, Pelayo S, et al. A comparative review of patient safety initiatives for national health information technology. *Int J Med Inform* 2013;82(5):e139–e148.
- [33] Palojoki S, Mäkelä M, Lehtonen L, Saranto K. An analysis of electronic health record-related patient safety incidents. *Health Informatics J*. 2016 March 7. [Epub ahead of print] doi: 10.1177/1460458216631072.
- [34] Kuusisto-Niemi S, Saranto K. Health and Human Services Informatics - Paradigmatic basis (In Finnish). *FinJeHeW* 2009;1(1):19–23.
- [35] Knuutila J, Ruuhilehto K, Wallenius J. Terveystieteen ja lääketieteellisten tutkimusten raportointi. [Adverse Events Reporting in Health Care]. *Lääkelaitoksen julkaisusarja 1/2007*. Helsinki: Lääkelaitos; 2007.
- [36] Larizgoitia I, Bouesseau MC, Kelley E. WHO Efforts to Promote Reporting of Adverse Events and Global Learning. *J Public Health Res* 2013;2(3):e29.
- [37] Chang A, Schyve PM, Croteau RJ, O’Leary DS, Loeb JM. The JCAHO patient safety event taxonomy: a standardized terminology and classification schema for near misses and adverse events. *Int J Qual Health Care* 2005;17(2):95–105.
- [38] Hsieh H, Shannon SE. Three Approaches to Qualitative Content Analysis. *Qualitative Health Research* 2005;15(9):1277–1288.
- [39] Merriam-Webster. Omission; 2016. Available at: <http://www.merriam-webster.com/dictionary/omission>. Accessed 21 July 2016.
- [40] Evans SM, Berry JG, Smith BJ, Esterman A, Selim P, O’Shaughnessy J, et al. Attitudes and barriers to incident reporting: a collaborative hospital study. *Qual Saf Health Care* 2006;15(1):39–43.
- [41] Kreckler S, Catchpole K, McCulloch P, Handa A. Factors influencing incident reporting in surgical care. *Qual Saf Health Care* 2009;18(2):116–120.
- [42] Levtzion-Korach O, Frankel A, Alcalai H, Keohane C, Orav J, Graydon-Baker E, et al. Integrating incident data from five reporting systems to assess patient safety: making sense of the elephant. *Jt Comm J Qual Patient Saf* 2010;36(9):402–410.
- [43] Christiaans-Dingelhoff I, Smits M, Zwaan L, Lubberding S, van dW, Wagner C. To what extent are adverse events found in patient records reported by patients and healthcare professionals via complaints, claims and incident reports? *BMC Health Serv Res* 2011;11(1):49.
- [44] Noble DJ, Pronovost PJ. Underreporting of Patient Safety Incidents Reduces Health Care’s Ability to Quantify and Accurately Measure Harm Reduction. *J Patient Saf* 2010;6(4):247–250.
- [45] Nuckols TK, Bell DS, Liu H, Paddock SM, Hilborne LH. Rates and types of events reported to established incident reporting systems in two US hospitals. *Qual Saf Health Care* 2007;16(3):164–168.
- [46] Pucher PH, Johnston MJ, Aggarwal R, Arora S, Darzi A. Effectiveness of interventions to improve patient handover in surgery: A systematic review. *Surgery* 2015;158(1):85–95.
- [47] Glassman P. The Joint Commission’s “Do Not Use” List: Brief Review. In: Agency for Healthcare Research and Quality. *Making Health Care Safer II: An Updated Critical Analysis of the Evidence for Patient Safety Prac-*

tices. Rockville (MD): Agency for Healthcare Research and Quality (US); 2013.

[48] Lahtela A, Hassinen M, Jylhä V. RFID and NFC in healthcare: Safety of hospitals medication care. Second

International Conference on Pervasive Computing Technologies for Healthcare; 2008.
doi:10.1109/pcthealth.2008.4571079.