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An Analysis of the Work System Framework for Examining Information Exchange in a Healthcare Setting

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Abstract:

Lack of communication is a leading root cause of sentinel events (any unanticipated event in a healthcare setting resulting in a patient's death or serious physical or psychological injury and not related to the natural course of the patient's illness). Deficits in communication of essential information when patients transfer between different healthcare services can cause interruptions in the continuity of care, inappropriate treatment, and potential harm to the patient. Research has shown that providing the right information about the right patient to healthcare providers at the right time could eliminate up to 18 percent of the general adverse events. In this paper, we assess the applicability of the work system framework (WSF) to evaluate the health information-exchange processes that occur when patients are transferred from home healthcare services and nursing homes to hospitals. From our analysis, we identify possible improvements in both work practices and the flow of health information among healthcare providers. Further, we propose a modified work system snapshot template tailored for evaluating the health information-exchange process. The proposed modifications include changing the WSF terminology to healthcare terms (including patient safety indicators) and adding new performance measurement indicators that are relevant to healthcare.

Keywords: Continuity of Care, Health Information, Hospitalization, Interdisciplinary Communication, Systems Analysis, The Work System Framework.

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1 Introduction

Lack of communication is the leading root cause of sentinel events in the US (The Joint Commission, 2015; Wheeler, 2015). Inaccuracy and incompleteness in information exchanged among healthcare providers is also a European issue (Kirsebom, Wadensten, & Hedström, 2013; Olsen, Hellzén, Skotnes, & Enmarker, 2014). In a study of 102 patient records of older inpatients admitted from home healthcare to medical wards at a Norwegian hospital, nursing admission notes were present only in 1 percent of the patient transfers (Olsen, Hellzén, & Enmarker, 2013). Poor quality and incomplete handovers between healthcare providers play a role in 80 percent of preventable adverse events (O'Reilly, 2010; The Joint Commission, 2015). Research has shown that providing the right information about the right patient to healthcare providers at the right time could eliminate up to an estimated 18 percent of the general adverse events and as many as 70 percent of the adverse drug events (Kaelber & Bates, 2007). Therefore, clear communication and accurate exchange of essential patient information is important for effective handovers when responsibility for care of patients shifts from one healthcare provider to another (Wheeler, 2015).

Deficits in communicating essential information when patients transfer between different healthcare settings and services can cause interruptions in the continuity of care, inappropriate treatment, and potential harm to the patient (Aase, Søyland, & Hansen, 2011; Coleman, 2003; Kripalani et al., 2007). Patients with continuous complex care needs, who require care in multiple settings, are particularly vulnerable to the lack of quality in information exchanges during handovers (Coleman, 2003). In addition to breakdowns in continuity of care, medication errors and adverse events can erode patient safety (Gleason et al., 2010; Hellström, Bondesson, Höglund, & Eriksson, 2012). Analyzing medication reconciliation errors and risk factors at hospital admissions, Gleason et al. (2010) found that over one third of the patients had a medication error at admission and that 85 percent of the patients had errors originate in their medication history primarily due to omissions. Medication errors can occur at all stages of the medication management process; however, they commonly occur at the medication administration stage (Hellström et al., 2012; Manias et al., 2014).

Communication at handover is the process in which one healthcare provider communicates information about a patient/resident care to another healthcare provider (Riesenberg, Leisch, & Cunningham, 2010). After systematically reviewing the literature on nursing handovers, Riesenberg et al. (2010) found the following barriers to effective handover communication: communication barriers, problems with standardization, equipment issues, environmental issues, a lack or misuse of time, difficulties related to complexity of cases or high caseloads, a lack of training or education and human factors. Several studies have explored barriers that influence the process of information exchange (Coleman, 2003; Olsen, Østnor, Enmarker, & Hellzén, 2013; Riesenberg et al., 2010), the quality of nurse documentation and information management across healthcare organizations (Hellesø, Lorensen, & Sorensen, 2004; Hellesø, Sorensen, & Lorensen, 2005; Jefferies, Johnson, & Griffiths, 2010), and how to improve information exchange between healthcare providers (Hustey & Palmer, 2010; LaMantia, Scheunemann, Viera, Busby-Whitehead, & Hanson, 2010; Riesenberg et al., 2010). However, we need more research to assess the effectiveness and outcome of patient handover by focusing on systems' factors and human performance measurement (Naylor, Kurtzman, & Pauly, 2009; Riesenberg et al., 2010; Sobolewski, 2011).

To study performance in the process of information exchange, some authors recommend studying the work processes and communication activities associated with information and communication practices (Georgiou, Marks, Braithwaite, & Westbrook, 2013; Unertl, Weinger, Johnson, & Lorenzi, 2009). Work processes or workflow factors include sequences of routine activities and tasks, relationships among activities, roles, and responsibilities and are influenced by internal or external factors (Unertl, Johnson, & Lorenzi, 2012; Unertl et al., 2009). Communication activities or information flow incorporate the transfer of information between individual actors (e.g., registered nurses (RNs) or other healthcare providers) (Unertl et al., 2009). From our perspective, Alter's (2013) work system framework (WSF) is an option for studying workflow and information flow-related aspects of health information-exchange activities in a healthcare setting. This framework provides a socio-technical perspective and system view for understanding information systems in organizations by including elements such as participants, customers, processes and activities, information, technologies, environment, infrastructure, and strategies. The WSF evaluation framework emphasizes work processes, activities, and human participants when evaluating work systems' performance (Alter, 2013). To our knowledge, no previous studies have used Alter's WSF and its performance-measurement indicators to analyze healthcare information systems. Thus, we focused on 1) applying the WSF to examine the current processes of health information exchange that occurs when patients are transferred from home healthcare services and nursing homes to hospitals, 2) identifying

possibilities for improving both work practices and the flow of information, 3) evaluating the applicability of the WSF framework in the healthcare setting, and 4) recommending modifications to the WSF elements to accommodate a healthcare-information system. Given this focus, we do not discuss the results from the case discussion in depth.

2 The Work System Framework

Alter (2010) proposes that one should think of work systems as socio-technical systems and service systems. A socio-technical system incorporates both an organization's technical and social elements (Fox, 1995). System services are "acts performed for someone else, including providing resources that someone else will use" (Alter, 2010, p. 201). Alter (2013) describes his model as a work system where humans and/or machines perform processes and activities using information, technology, and other resources to produce products and services for internal and external customers. Figure 1 visually represents a work system.

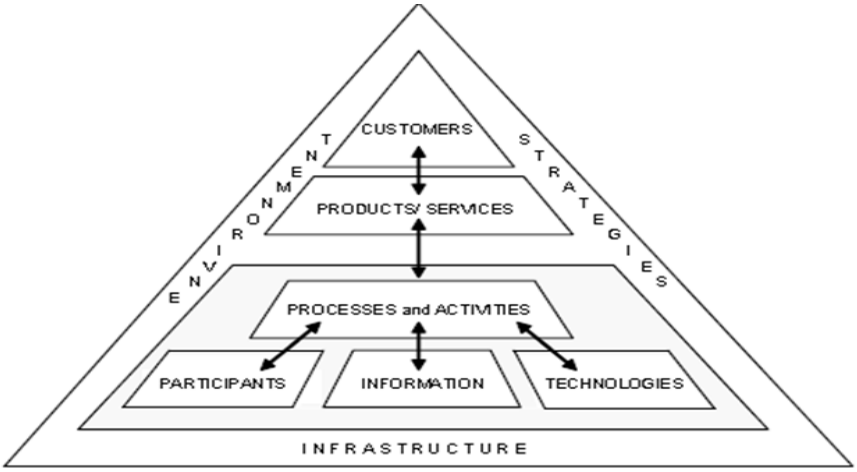

Figure 1. The Work System Framework (Alter, 2013, p. 78)

The WSF includes nine elements that form the basis for describing and analyzing a work system in an organization (Alter, 2013). However, processes and activities, participants, information, and technology are the basic components that actually perform the work. The framework includes products/services and customers because systems produce products and services for both internal and/or external customers. The framework includes strategies as an element because organizations should align their work systems and strategies (Alter, 2013). A work system's success also depends on how well it fits with the surrounding environment and uses the available infrastructure. Arrows between elements indicate that the various elements should be aligned. We further define the nine elements in Appendix A.

The "work system" is the unit of analysis and the central idea in assessing systems in organizations. One can use the work system framework for understanding and analyzing a work system at various levels of depth or a particular concern (Alter, 2013). To evaluate a system's performance, Alter (2006) presents performance-measurement indicators for each element of the work system. Alter intended these indicators to measure performance in the business sector; however, one can also apply certain elements and indicators to workflow and information flow-related aspects of information-exchange activities in a healthcare setting.

In the process of analyzing a system's performance, one uses the work system snapshot template (Alter, 2012) as a tool for summarizing a particular work system (Alter, 2006, 2013). The work system snapshot comprises six central elements of a work system: customers, products/services, processes and activities, participants, information, and technology (see Appendix B). In combination with the relevant performance measurement indicators, one also uses the template as a tool for identifying gaps and improvements in the work system and to compare the "as is" to the recommended "to be" of the work system (Alter, 2006, 2013). In Section 3, we examine how the elements of the WSF align with the services involved in the health information exchange when patients transfer from home healthcare settings and nursing homes to hospitals.

3 A Work System View on Health Information Exchange

In our study, we consider a system view of health information exchange as a service system that provides information to other healthcare providers (Alter, 2010). In this section, we discuss how the nine elements of the WSF (Appendix A) align with services involved in the health information exchange when patients transfer from home healthcare settings and nursing homes to hospitals.

3.1 Products and Services

The quality of the communication and information about the patients' current condition, patient care, and medical treatment during handover corresponds to the products and services element in the WSF (Alter, 2010). Handover communication and health information exchange from community service organizations (home healthcare and nursing homes) to the local hospital represents the services to provide continuity of care and improved patient outcomes (Crilly, Chaboyer, & Wallis, 2006; Naylor et al., 2009; Olsen et al., 2013).

3.2 Customers

The healthcare setting has several types of customers. Patients are customers in the sense of receiving care after they move to the hospital. One may also view patients' family or close relatives as customers because they are the ones who have a vested interest in patients' wellbeing (Georgiou et al., 2013; Kirsebom et al., 2013). RNs at the hospital are customers because they receive patient information from patients' care providers (Georgiou et al., 2013). One may treat the hospital as an organization and the government as external customers because they are responsible for the overall healthcare quality for the community (Georgiou et al., 2013).

3.3 Participants, Processes, and Activities

Healthcare providers from the community service organizations, who are responsible for communicating and exchanging health information during handover, are participants. They are responsible for the performance of workflow- and information flow-related activities that are included in the health information exchange to the hospital (Carayon et al., 2006; Georgiou et al., 2013). These information exchanges related aspects of work correspond to processes and activities element in the WSF.

3.4 Information and Technology

In the process of health information exchange, the participants need to manage and use information and technology (Carayon et al., 2006; Georgiou et al., 2013). Information could be handwritten or electronic information about patients, admission note forms, guidelines, and checklists. Information technology includes personal computers and software, telephones, and faxes.

3.5 Environment, Infrastructure, and Strategies

Participants should adhere to environmental aspects such as internal routines, culture, and policies of information management and health information exchange in their organization (Georgiou et al., 2013; Naylor et al., 2009). Organizational infrastructure and strategies also influence the performance of health information exchange (Kodner & Spreeuwenberg, 2002; Naylor et al., 2009; World Health Organization, 2013).

To apply and evaluate the WSF in the context of health information exchange, we focus on examining the participants' (e.g., healthcare provider, RNs, etc.) workflow performance- and information flow-related activities. In Section 4, we present the alignment of the selected WSF elements and performance-measurement indicators.

4 Application of the Work System Framework for Analyzing Health Information Exchange

As guidelines to analyzing health information exchange, we selected performance-measurement indicators that correspond with the healthcare setting in general and the system of patient health information exchange specifically. Following the work system approach for information system evaluation, we focused on analyzing the four basic elements that actually perform the work: 1) processes and activities, 2) participants, 3) information, and 4) technology (Alter, 2006). Below, we discuss selected

performance measurement indicators (see Table 1) relevant to the four basic elements of the WSF and present specific examples on how they are instituted in a healthcare setting.

Table 1. Performance-measurement Indicators Related to Exchanging Health Information and the Four Basic Elements in the Work System Framework (Alter, 2006)

Basic elements of the WSF	Performance measurement indicators
Processes and activities (work practices)	Efficiency, consistency, vulnerability, structure, coordination, clarity of messages, communication and control
Participants	Skills, knowledge, experience, job satisfaction, motivation, and engagement
Information	Ease of access, accuracy, precision, completeness, conciseness, and relevance
Technologies	Adequate technology (software and hardware), functional capability, ease of use, uptime, reliability, and compatibility with complementary technologies

4.1 Processes and Activities

In our study, processes and activities are the sequences and details of the work, such as the management of information and admission notes (workflow) and the methods and technology used to exchange health information with the hospital (information flow). According to Alter (2006), efficiency, consistency, and vulnerability are the three most important performance-measurement indicators for analyzing work processes and activities. In healthcare, the degree of efficiency can refer to how quickly the hospital receives patient information (timeframe), how correct and complete the information is (effectiveness), and the methods and tools used for the information exchange (e.g., written, verbal or electronic). Efficiency is especially important because the receipt of timely information increases the hospital staff's preparedness for receiving patients (Melby & Hellesø, 2010) and helps avoid adverse events. Delay in the documentation in the health information-exchange (handover) process may lead to inaccurate and incomplete record-keeping and could impact patient safety (Harrison, Koppel, & Bar-Lev, 2011).

Consistency refers to the standard routines for health information exchange. These routines impact the continuity, quality, and safety in patient healthcare (Georgiou et al., 2013; Van Houdt, Sermeus, Vanhaecht, & De Lepeleire, 2014). A standardized patient handover process following policies and formal guidelines/procedures is important to ensure the best health information exchange (Aase et al., 2011; Riesenberg et al., 2010).

When measuring system vulnerability, inadequate guidelines and low-quality control are risk factors in an organization (Alter, 2006). In the healthcare setting, minimizing risk is key to managing patient-safety issues. Other performance-measurement indicators to evaluate the health information exchange include structure, coordination, clarity of messages, communication, and control (Alter, 2006). Structure in healthcare services can relate to organizational structure and the degree of how structured the information exchanged is. For organizational structure and coordination, roles need adequate definitions (Alter, 2006); for example, a formal structure designating who is responsible for exchanging health information to the hospital staff (Georgiou et al., 2013; Hellesø et al., 2005; Van Houdt et al., 2014).

Examples for how one can measure the clarity of messages in healthcare include quality, accuracy, structure, and content of the information (Georgiou et al., 2013). One can measure clarity by what verbal, handwritten, or electronic health information exchanges a healthcare provider provides to a hospital and to what extent the hospital needs to request further information. The quality and accuracy of the exchanged information is important for consistent patient care (LaMantia et al., 2010; Riesenberg et al., 2010; World Health Organization, 2013). The health information exchanged should be standardized, structured, and integrated into the electronic health record (EHR) (Hustey & Palmer, 2010; Jefferies et al., 2010; Riesenberg et al., 2010). In addition to guidelines for exchanging information, procedures should be established for handling deviations.

4.2 Participants

RNs, nursing aids, and nursing unit managers are the usual staff in Norwegian home healthcare and nursing homes. RNs commonly have the main responsibility for exchanging patients' health information (Hellesø et al., 2005; Johnsen, 2012). Therefore, RNs are the participants in our study.

Alter (2006) emphasizes the importance of participants as more than just technology users. He states that the efficiency of the work and the quality of the outcome depends on the participants. One can evaluate participants' performance based on their skill, knowledge, and experience (Aase et al., 2011; Alter, 2006; Riesenberg et al., 2010). Certain RNs use computers and information systems extensively for documenting patient information, whereas others use little or no technology depending on their computer skills. Knowledge, skills, and experience in relation to communication and health information exchange is essential in healthcare (Grönroos & Perälä, 2005; Van Houdt et al., 2014). In addition, RNs should have general knowledge of information flow in healthcare (Coleman & Boult, 2003) and the healthcare reforms that exist between hospitals and municipalities on health information exchange. Also, the amount of training time the RNs have received on the health information exchange process may impact their performance (Alter, 2006).

Other participant performance-measurement indicators are job satisfaction, motivation, and engagement (Alter, 2006). Health information exchange depends on appropriate technology, information, and structured work processes, but participants who are not fully engaged and not motivated to learn or use formal guidelines will interfere with the quality of the health information exchange. In addition, research has found organizational conditions that affect RNs' work processes and motivation (Aase et al., 2011; Carayon et al., 2006; Riesenberg et al., 2010).

4.3 Information

Information in relation to health information exchange is the available information RNs have access to when preparing to transition a patient to a hospital. This information includes codified information (i.e., formal guidelines/procedures on information exchange) (Hellesø et al., 2005) and non-codified or informal information (i.e., RNs' internal methods of exchanging health information; for example, culture about how one should write hand notes and verbally exchange information.) (Hellesø et al., 2005; Jenkin, Abelson-Mitchell, & Cooper, 2007; Van Houdt et al., 2014). According to Alter (2006), ease of access, accuracy, precision, completeness, conciseness, and relevance are important performance-measurement indicators to analyze information systems. Ineffective data storage (paper based vs. electronic) and inconsistencies when presenting patient information (e.g., unstandardized documents, missing information, verbal versus written, etc.) can result in situations where valuable information is not available to healthcare providers to help safely and effectively transfer patients (Georgiou et al., 2013). A standardized admission note is an example of an artifact to evaluate information performance and quality (Aase et al., 2011; LaMantia et al., 2010; Riesenberg et al., 2010).

4.4 Technology

The tools and technologies RNs use when preparing and performing the health information exchange could be a personal computer (PC), a small handheld computer (personal digital assistant (PDA), telephone, and/or fax machine. Technologies also include software applications such as an electronic health record, patient care plan, or admission note. According to Alter (2006), adequate technology (software and hardware), functional capability, ease of use, uptime, reliability, and compatibility with complementary technologies are important performance-measurement indicators for technology.

5 Methods

5.1 Design and Methods

We used both qualitative and quantitative methods to understand the current status of the health information-exchange process and to populate work system snapshot templates. We collected data from semi-structured interviews, document analyses, and a survey. We conducted the interviews and analyzed documents to develop the survey questions. Documents we analyzed included guidelines, admission note forms, and checklists to ensure that all relevant information was sent to the hospital.

5.2 Setting

We conducted this study in two home healthcare services and two nursing homes located in two different counties in southern Norway. The participants for the individual semi-structured interviews all worked in the unit for at least one year, held a clinical position at least 50 percent of the time, and knew about the current procedures used for information exchange in acute patient admissions to hospitals.

5.3 Methodology

Data collected comprised 1) four individual semi-structured interviews 2) an analysis of documents relevant to the information exchange, and 3) a survey of 52 respondents. We interviewed one RN from each of the four healthcare service organizations. All 79 RNs in the two different counties received a survey. A total of 52 (66%) RNs responded (home healthcare services A (n = 13), home healthcare services B (n = 10), nursing home A (n = 13), and nursing home B (n = 16).

The semi-structured interview guide contained questions based on the four basic elements and performance-measurement indicators from the WSF. We obtained documents that were available and relevant to the health information exchange. We analyzed the documents and compared them among the four settings. We analyzed the qualitative interview data using qualitative content analysis and coded the data according to the elements of the WSF using the work system snapshot template (Alter, 2012) (see Appendix B). We used two separate templates to summarize the results of the interviews and document analysis: one for the two home healthcare services and one for the two nursing homes. Tables 2 and 3 presents the two templates with results of the interviews.

Table 2. Work System Snapshot for the Two Home Healthcare Services on the Current Health Information Exchange

<table>
<tr><th>Customers</th><th colspan="2">Products and services</th></tr>
<tr><td>Healthcare personnel
Patients and relatives
Organization and government</td><td colspan="2">Current patient health information received from home healthcare services</td></tr>
<tr><th colspan="3">Processes and activities</th></tr>
<tr><td colspan="3">Healthcare personnel contact the patient’s doctor or the emergency department requesting a patient be transferred to the hospital. Although RNs have the formal responsibility for the patient information exchange, sometimes other personnel have to take care of this activity.
Most of the patient information is given verbally to the ambulant doctor and personnel. A lot of this information is given via phone. One of the two home healthcare services uses only a phone for health information exchange because it considered the phone a fast and easy way to exchange information when it could not do so electronically.
Personnel use informal routines (culture) to exchange health information that they know.
Healthcare personnel send medication and necessary contact information (of relatives and the home healthcare office) with the patient. Sometimes they send handwritten notes or admission notes with the patient.
One of the two home healthcare services faxes patient information when they get back to their office.
The two home healthcare services often have to delay their documentation. The one service that has a PDA may write a note on the admission but can’t send electronic admission notes to the hospital. The PDA is not connected to a shared health network. Documentation varies in structure and content.
An RN has to call the hospital to check if they received the envelope or if they have to fax more information.
Sometimes patients get admitted to the hospital without the assistance from the personnel from home healthcare services. Then the patients or their relatives have to transmit the health information. In such a case, the hospital sometimes calls for more information.
The home healthcare services do not get a receipt from the hospital on the received information, but they get a receipt when faxing information to the hospital.</td></tr>
<tr><th>Participants</th><th>Information</th><th>Technologies</th></tr>
<tr><td>Experience and skills vary in documenting in EHR.
RNs have the formal responsibility for health information exchange and have to make a judgment call on what information to send.
Routines for health information exchange are part of the culture in the two home healthcare services.
Time pressures and large distances from their home healthcare office influences the health information-exchange process.</td><td>A formal procedure is available at one of the offices but not yet officially in use because they are still working on it.
None of the home healthcare services have a standardized electronic admission note.
One of the home healthcare services recently acquired a paper-based standardized admission note that they plan to putt in their cars and start using.
None of the home healthcare services use a care plan for their patients.
There is a lack of information about some patients in the home healthcare services due to a limited need of health services.</td><td>The two home healthcare services have two different EHR systems.
They always exchange health information over phone or fax.
They can receive and send electronic messages to the general practitioner’s (GP) office via a national health network.
They can receive but not send messages electronically to the hospital.</td></tr>
</table>

Table 3. Work System Snapshot for the Two Nursing Homes on the Current Health Information Exchange

<table>
<tr><th>Customers</th><th colspan="2">Products and services</th></tr>
<tr><td>Healthcare personnel
Patients and relatives
Organization and government</td><td colspan="2">Current patient health information received from nursing homes</td></tr>
<tr><th colspan="3">Processes and activities</th></tr>
<tr><td colspan="3">Health personnel contact the patient's doctor or the emergency department. Although RNs have the formal responsibility, other personnel have to sometimes take care of the information exchange.
For the health information exchange, they use a formal procedure.
If they lack the ability to electronically exchange health information, they send an envelope (with or without a checklist) with the patient to the hospital. They also provide verbal information to the ambulant personnel.
Paper-based admission notes are both electronic (hardcopies) and handwritten and vary in structure and content. The content of the admission note often depends on the RNs' skills and experience with an EHR.
As a method of information exchange, they send important medication with the patient to hospital.
The nursing homes do not obtain a receipt from the hospital on received health information. Envelopes have got lost in the ambulance.
An RN has to call the hospital to check if they have got the envelope or if they have to fax more information.</td></tr>
<tr><th>Participants</th><th>Information</th><th>Technologies</th></tr>
<tr><td>Experience and skills vary in documenting in EHR.
RNs have the formal responsibility for exchanging health information and have to make a judgment on what information to send. They can choose to use formal or informal routines.</td><td>The formal procedures available vary in content between the two institutions.
None of the institutions have a standardized electronic admission note.
One of the institutions has a paper-based standardized admission note they can use if they don't have time to write in the EHR.</td><td>The institutions have two different EHR systems and experience different functionality.
They sometimes exchange health information over the phone or fax.
They can receive and send electronic messages to the general practitioner's (GP) office via a national health network.
They can receive but not yet send messages electronically to the hospital.</td></tr>
</table>

Based on comparing the data from the two templates, we formed common "subcategories" that we used to illustrate current health information exchange processes (Graneheim & Lundman, 2004). We used these subcategories to develop the survey instrument (Appendix C). Table 4 shows the subcategories and examples for the types of questions asked.

Table 4. Subcategories Collected from Analyzing the Data from the Interviews and Examples of Questions Used in the Survey Instrument

Subcategories	Related types of questions
Timeframe	Is the information sent with the patient (immediately) or forwarded (later)?
Methods/format	What types of technology or methods are used to send the information to the hospital?
Forms of exchanging healthcare information	In what form is the information sent to the hospital? Verbally via other personnel, through medicine dosage, via various copies, or handwritten notes?
Structure of exchanged information	Is the information predefined or handwritten text or electronic notes?
Request for further information	Does the hospital receive sufficient information or is there need for additional information?
Responsibility	Is formal responsibility practiced?
Control routines	Is a checklist used for submitted information? Does one receive an acknowledgement of the information sent to the hospital?
Guidelines and procedures	Does one use formal and/or informal procedures for information exchange?
RNs' experience and knowledge	Are RNs trained in the information exchange process? Are they familiar with current responsibilities/policies/ procedures?

The survey instrument contained demographic questions such as the number of years that the participants had worked as an RN and the number of years at their current workplace. We asked the RNs to grade the frequency of various subcategories (Table 4) of information exchange. We used a five-point Likert scale (1 = never; 5 = always) (Polit & Beck, 2010). We measured questions about knowledge based

on the level of official training the RNs had in formal and informal procedures. We validated the survey instrument in a pilot study. The small sample groups limited the degree of statistical analysis.

5.4 Ethical Considerations

We obtained permission from the two nursing homes and two home healthcare services and written consent from the participants. The Norwegian Social Science Data Services (NSD), number 28227, approved the study.

6 Findings

In this section, we present the results of the survey according to the subcategories that we used as themes in the survey instrument (Table 4). We used information that we gained from the interviews as supplemental data.

6.1 Timeframe of Information Exchange

We found that the home healthcare services and nursing homes did not follow the same workflow in the health information-exchange process. When transferring a patient to a hospital, home healthcare services forwarded health information more frequently than nursing homes. One of the RNs from the home healthcare services stated that technological challenges and lack of time were common reasons why they had to postpone exchanging documentation and health information. The RNs from the second home healthcare services district confirmed that they were not always able to send documentation with the patient. They often faxed the health information retrospectively (e.g., the medical list and/or user card/patient card). Both of the nursing homes sent the necessary health information/documentation with the patient to the hospital. They only used fax when the hospital requested additional documentation. These findings correspond with results from the survey.

6.2 Methods and Tools for Health Information Exchange

The three most frequently used methods for sending health information were a regular envelope (m = 3.36), the phone (m = 3.35), and an envelope with an attached checklist (m = 2.54). Home healthcare services used the phone and fax more frequently than nursing homes. A participant from the home healthcare services reported that using the phone was an effective way to share health information, and the phone was their current method for exchanging health information. It was faster for the home healthcare RNs to make a phone call than to drive down to the home healthcare office and print the EHR documents. One of the participants from a nursing home expressed concern about using a phone for exchanging health information. He had experienced that reporting between foreign healthcare personnel via the phone can lead to misinformation or miscommunication due to language barriers. Nursing homes reported more commonly using an envelope.

A majority of all the RNs (84%) stated that they never use email as a method for health information exchange. They recognized that it is not legal to use regular (unsecure) email for exchanging personal health information and they did not mention using email as a tool for exchanging health information. Even though regular email is illegal, one RN answered in the survey “now and then” and one answered “always” to the question of how often email was used for exchanging health information.

Only 8 percent of the RNs “sometimes or frequently” used an electronic link directly to the hospital. This answer could have resulted from the RNs’ misunderstanding the question because RNs interviewed from both home healthcare services and nursing homes stated that they could send and receive messages electronically from the general practitioner’s (GP) office but could not yet send information electronically via the Norwegian Health Network (NHN) to the hospital. However, at the time of this study, the hospital had the ability to send health information electronically via the NHN to the home healthcare services and nursing homes. A total of 90 percent of the RNs answered that they had never used a PDA for health information exchange to the hospital. This result corresponds with information from the participants that only one of the home healthcare services in the study used PDAs. At the time of the survey, this home healthcare service was not able to send health information from the PDA to the hospital or to retrieve messages sent from the hospital. Despite these challenges, the participants perceived that the PDA was a useful tool and a source for information (e.g., the RNs had access to the EHR, medication catalogue, and procedures through the PDA).

6.3 Forms of Health Information Exchange

A majority of the RNs (80%) answered that they "always or often" informed the emergency medical or ambulance personnel verbally so that necessary information should be listed in their transfer note. We confirmed the fact that the RNs widely used verbal information when exchanging health information in the interviews with the two different healthcare services.

The type of health information exchange that occurred most frequently was a copy of the medication list/medication card (m = 4.44) sent with the patient. The average value was slightly higher at the nursing homes (I/A: m = 4.92 and I/B: m = 4.94) than at the home healthcare services (H/A: m = 3.85 and H/B: m = 3.80) (we refer to the two healthcare services as "I" for institution (nursing home) and "H" for home healthcare services). Sending copies of the user card/patient card and of health records also occurred more frequently at the nursing homes than at the home healthcare services because the nursing homes had access to the patient's electronic health record (EHR) and the ability to print out information on location. However, home healthcare services often sent a medicine pill box, a medical list or multi-dose containers together with the patients to a greater extent than the nursing homes (H/A: m = 4.23 and H/B: m = 4.00 to I/A: m = 2.67 and I/B: m = 2.94).

RNs sent handwritten admission notes with the patient less often (m = 2.63) than copies of the electronic medical record/report (m = 3.12). A majority of respondents (64%) answered that they "seldom or now and then" sent handwritten admission notes. Nevertheless, certain respondents in nursing homes and home healthcare services in county A answered that they "often" (I/A: 23% and H/A: 23%) sent handwritten admission notes. Therefore, in conclusion, we found no consistency in the format of the information exchange among the organizations.

6.4 Structure of Exchanged Health Information

The survey shows that the documentation exchanged had varying degrees of structure among the healthcare services and in the different services. In the home healthcare services in county A, the same amount of participants responded that they often (23%) or never (23%) sent handwritten admission notes in a free text format. However, most of the participants (66%) from both community services and counties responded that they never or seldom sent handwritten admission notes in a free text format. The admission notes from the nursing homes had more structure. In total, 59 percent of the respondents from the two nursing homes responded that they often or always used electronic admission notes with a predefined structure versus 34 percent of the respondents from the two home healthcare services. Of all the respondents from both community services and counties, 40 percent responded that they never used electronic admission notes with a predefined structure. According to a participant from one of the nursing homes, the degree of free-text, structure, and the amount of information in electronic admission notes depended on the individual RN. Therefore, in conclusion, we found no consistency in the structure of the information exchanged among the organizations.

According to participants interviewed from both home healthcare services, healthcare providers rarely used care plans. This result is consistent with the survey responses that showed lower average values for the use of structured care plans at home healthcare services (H/A: m = 2.62 and H/B: m = 1.6) compared with those at nursing homes (I/A: m = 4.08 and I/B: m = 2.88). According to one of the participants, this situation may be due to healthcare providers' heavy workload and time constrains and to a lack of available health information about some patients in home healthcare with a limited need of healthcare services. One of the nursing homes had experienced issues in implementing a care plan/treatment plan in the EHR system, which had led to their return to using paper-based care plans until they solved the technical problems.

6.5 Request for Further Health Information

The average values for how frequently the hospital needed to request further health information were higher for home healthcare services (H/A: m = 3.1 and H/B: m = 3.4) than nursing homes (I/A: m = 2.5 and I/B: m = 2.4). At the home healthcare service, which gave only verbal information for acute hospitalization of patients, 92 percent of the respondents answered that the hospital requested further health information "now and then".

6.6 Responsibility, Safety, and Control

All four participants interviewed stated that RNs' had the responsibility of exchanging health information when patients moved to a hospital; however, other staff occasionally had to give the health information to the hospitals. The nursing homes used checklists more frequently than the home healthcare services to ensure that they delivered sufficient information with the patients. One nursing home used a checklist attached to the envelope. According to the participant from the other nursing home, they used their guidelines/procedure as their checklist. A total of 96 percent of survey respondents answered that they "never or seldom" obtained an acknowledgement from the hospital for the envelope received with the admitted patient or the forwarded information. The participant from the home healthcare service that sent faxes said that she obtained a receipt from the hospital for a received fax. Participants reported that occasionally envelopes had gone astray because they were left behind in the ambulance or in the emergency department. In these cases, the hospital reported the envelope missing.

6.7 Guidelines and Procedures

Three of the four community service organizations had formal guidelines/procedures related to hospitalizing patients. However, the key participant at one of the home healthcare services district (B) explained that they had not yet fully implemented their formal guidelines because they were still developing them. The other home healthcare service (A) could not provide formal guidelines/procedures for admitting patients to hospital. However, the participant claimed that the procedures were known to the staff. One staff member explained: "That's how we do it today, and that's the way we've done it for years, so it is somehow incorporated among our nurses".

The formal guidelines/procedures that did exist among the community service organizations were quite different both in terms of content and structure. Only one of the four community service organizations had included in the guidelines that RNs should write a note on the admission and give the reason for admission and details of the exchanged documentation. The participant from this nursing home emphasized the importance of securing legal evidence through documentation. Only one of the healthcare services included instructions on how to handle deviations in their formal guidelines/procedures.

6.8 Registered Nurses' Experience and Knowledge

Approximately 27 percent of the survey respondents in home healthcare services and nursing homes had worked between 11 and 15 years as RNs. A large number (60%) of respondents had only worked between 0 and 7 years at their current workplace.

Among the respondents, 55 percent reported that the manner in which they exchanged health information based on internal formal guidelines/procedures. The majority (86%) of these respondents belonged to nursing homes that had formal guidelines/procedures. The second largest group (33%) comprised respondents who did not know if the health information exchange took place according to formal guidelines. Forty-four percent of the respondents claimed the exchange of health information took place using informal routines.

A total of 55 percent of the respondents answered that they had received training in formal procedures and 45 percent answered that they had not received training or did not know if they had been trained in the current formal guidelines on health information exchange. As many as 77 percent of the respondents in the survey agreed that they had received training in current routines for health information exchange.

Most of the respondents (75%) reported that they knew their professional and legal responsibilities relative to documentation and health information. However, the fact that RNs used handwritten admission notes violates professional responsibility and legal regulations. Participants explained this violation as resulting from RNs' lack of experience and motivation in using electronic documentation.

7 Discussion

In Section 5, we present an example of how to apply the WSF and the work system snapshot. In Section 7.1, we discuss suggestions for improvements in the health information exchange process using the "to be" snapshot. In Section 7.2 and 7.3, we discuss the applicability of the WSF framework to the healthcare setting. In Section 7.4, we recommend modifications to the six WSF central elements to accommodate a healthcare information system.

7.1 Health Information Exchange Improvements

Based on the "as is" view of the current health information exchange derived from the work system snapshots (Table 2 and 3) and the survey, we identify several recommendations for improvement (see Table 5).

Table 5. Work System Snapshot of Possible Improvements ("To Be" Work System) in Health Information Exchange for the Two Community Services

<table>
<tr><th colspan="2">Customers</th><th>Products and services</th></tr>
<tr><td colspan="2">Change relationship to hospital
Change patients' experience of care</td><td>Timely, accurate, comprehensive patient information
Continuity of care</td></tr>
<tr><th colspan="3">Processes and activities</th></tr>
<tr><td colspan="3">Practice formal responsibility.
Consistency in using methods for health information exchange.
Improve the general processing of health information.
Consistency in structure and content of health information exchanged.
Reduce verbal communication.
Document verbal exchange of health information.
Reduce postponing health information exchange.
Use electronic message exchange via the Norwegian Health Network.
Abandon old guidelines/procedures and work practices on electronic message exchange implementation.
Improve health information security by assuring that patient information does not go astray.</td></tr>
<tr><th>Participants</th><th>Information</th><th>Technologies</th></tr>
<tr><td>Provide training for documentation in EHR.
Provide resources required to do the work.
Facilitate health professionals' adherence to professional and formal obligations.
Change organizational structure.
Change the amount of pressure that participants feel.
Ensure understanding of details of tasks and use of appropriate information and knowledge in exchanging health information.
Ensure that participants understand the meaning and significance of exchanging health information
Change culture about using computers.</td><td>Access to health information in patients' homes.
Formal guidelines/procedure on exchanging health information.
Formal guidelines/procedure on documentation in EHR.
Formal control routines for documenting and exchanging health information.
Same formal procedures used in same county.
Structured and standardized electronic admission note.
Electronic care plan in EHR
Codify currently uncodified or tacit knowledge.
Improve health information quality.
Implement individual care plans.</td><td>Upgrade software and/or hardware to functional and compatible systems.
Incorporate the ability to receive and send messages to the hospital from both the nursing homes and the home healthcare service offices and from PDAs.
Incorporate PDAs in all home healthcare services.
Make technology easy to use.</td></tr>
</table>

7.2 Evaluating the Applicability of the WSF to a Healthcare Setting: Challenges

We experienced four challenges when using the WSF: 1) selecting appropriate performance measurements indicators, 2) limiting the scope of the elements because of their interdependence, 3) differentiating among certain elements in the framework, and 4) ensuring further internal alignment between the WSF elements.

7.2.1 Performance Measurement Indicators

The fact that researchers have primarily used the work system snapshot to analyze systems in business terms required that we formulated a new list of performance-measurement indicators for each WSF element for the healthcare setting. From Alter's (2006) lists of performance-measurement indicators, we selected indicators that associated best to a healthcare setting. For example, we chose indicators such as messages' efficiency, consistency, and clarity because the degree of standardization in patient health information documentation and communication is important for continuity of patient care and has further effects on the information quality and patient safety.

We chose structure and coordination as essential indicators to clarify the responsibilities and tasks when exchanging health information to the hospital. However, we found that performance-measurement

indicators such as activity rate, output rate, and speed were more appropriate for analyzing health information systems as a tool. In our opinion, performance-measurement indicators such as quality of decisions and degree of consensus attained are more appropriate for business professionals. Overall, the existing indicators selected were meaningful, but, to relate the indicators to a healthcare setting, we had to rename several indicators. For example, we modified the term consistency to standardization in work routines and the use of formal guidelines. Instead of coordination, we used responsibility, and we replaced vulnerability with patient safety issues and information security.

To evaluate communication, Alter (2006) presents three different but similar indicators: clarity of messages, absorption of messages, and completeness of understanding. We chose clarity of messages because it could relate to both the quality and accuracy of patient information sent to hospitals. Clarity of messages also measures how well the hospital staff finds the health information understandable, appropriate, and comprehensive (depending on the use tools; e.g., phone, fax, handwritten notes, or copies of the patients' EHR). In our study, we chose not to examine how the hospital staff experienced the quality, content, and comprehensiveness of received health information from the two community services. We only asked the survey respondents how often the hospital requested more health information and how often the hospitals need of health information differed from what the community services sent.

7.2.2 Scope

We found it challenging to limit our analysis to the work system itself and just focus on the processes and activities (work practices), participants, information, and technology. As an example, we found that organizational factors such as time pressure and poor nursing coverage could affect the RNs' work processes and motivation. Organizational aspects such as poor nurse coverage also seemed to impact the formal regulations about how RNs should exchange health information to hospitals. This observation suggests that environmental and organizational issues may also cause barriers to effectively exchange health information.

7.2.3 Differentiation among Elements

We categorized our work system as a service system for health information exchange and not as a service system for information management because we didn't evaluate nursing documentation of patient health information specifically. Using Alter's (2006) lists of performance-measurement indicators for each element made it possible to define the elements that fit with service systems in healthcare organizations. Nevertheless, we found it difficult to differentiate among certain elements in the framework. For example, information as an element could represent a product of the RNs' tacit knowledge or knowledge based on culture among RNs, and, at the same time, it could represent information (e.g., journal notes with patient data) found in an EHR system. An EHR system may represent a tool/technology but can also represent a source of information (database/software). Truex, Alter, and Long (2010) experienced similar difficulties in categorizing the work system and confusion about each element's definition.

7.2.4 Internal Alignment

Double-headed arrows between the elements of the original model of the WSF (Figure 1) express the need for internal alignment. However, the WSF has no double-headed arrows between participants and information or between information and technology. The issue we had differentiating among these three elements could imply the need for a double-headed arrow between these elements. Such a need for further alignment corresponds to findings made by Granlien (2010). A drawback of the framework is that it does not assess the interactions of these elements. For example, one could examine the quality of RNs' (participants) documentation of health information (information).

7.3 Evaluating the Applicability of the WSF to a Healthcare Setting: Advantages

Despite the challenges we mention in Section 7.2, using the template to summarize and organize the data from the interviews made it easier to visualize, organize, and identify different gaps in how the home healthcare services and nursing homes exchanged health information with hospitals. Further, we found the work system snapshot useful in ensuring validity and reliability to our pilot study. The work system snapshot enabled construct validity by helping us choose which elements to include and which performance measurement indicators were relevant to our systems analysis of health information exchange. To ensure content validity, we conducted preliminary interviews with RN's in the setting we investigated. Using the work system snapshot to organize our findings from the interviews and viewing the

"as is" system of health information exchange made it easier to identify gaps and commonalities and differences among the nursing homes and home healthcare districts. Moreover, we developed valid questions and variables for a common survey. Conducting the survey provided more reliable results and enabled us to create a "to be" snapshot of possible improvements.

Using the WSF, we could also analyze the various elements and their corresponding performance-measurement indicators. Doing so helped us quickly identify areas needing improvement. Gaps we identified included lack of practicing formal responsibility, lack of formal guidelines, and lack of using standardized admission notes. We also found that RNs were unaware of formal procedures and did things because "that is just how we do it". The evaluation also showed that RNs extensively used handwritten and verbal information when transferring patients and that envelopes sometimes went astray. Using the performance-measurement indicators to analyze current health information exchange made it possible to identify continuity of patient care and safety issues.

In sum, with the WSF framework, we established a deeper understanding of the system's scope and operations. Further, the framework provided an organized yet flexible structure for analyzing the current health information exchange and identifying possible needs for change.

7.4 A Work System Snapshot Template for Examining Health Information Exchange

Today, the WSF model focuses on the business environment; however, we believe it could be easily adapted for the healthcare environment by including performance-measurement indicators that align with healthcare. To adapt the WSF to a healthcare domain, we suggest a work system snapshot template that contains healthcare-performance measures (see Table 6).

Table 6. Work System Snapshot with Suggested Performance Measures for Exchanging Health Information

<table>
<tr><th colspan="2">Customers</th><th>Products and services</th></tr>
<tr><td colspan="2">Relationship to other healthcare providers
Patients' experience of care</td><td>Timeliness, accuracy, comprehensiveness, and sufficiency of patient information
Continuity of care</td></tr>
<tr><th colspan="3">Processes and activities</th></tr>
<tr><td colspan="3">For work practices/work flow:
Consistency: standardization in work routines and in structure and content of health information exchanged.
Practice of formal routines.
Consistency in using methods and tools for exchanging health information.
Structure/coordination: practicing formal responsibility.
Efficiency: timeliness of health information exchanged.
Effectiveness of health information exchange.
For communication/information flow:
Clarity of messages: the quality and accuracy of health information exchanged depending on what methods are used (verbal, written, or other forms) to exchange health information.
Completeness of understanding: is the health information exchanged understandable and in accordance with the needs of the receiving healthcare providers.
Vulnerability: patient safety issues and health information security.</td></tr>
<tr><th>Participants</th><th>Information</th><th>Technologies</th></tr>
<tr><td>Skills/experience.
Knowledge of available information/guidelines.
Job satisfaction.
Motivation/engagement.
Training (formal/informal).
Acceptance of technology.
Culture.</td><td>Ease of access.
Available guidelines/ procedures (formal/informal).
Precision/completeness: standardization of information.
Relevance: protocols/checklists.
Accuracy: available individual treatment plan.</td><td>Available hardware/software.
Other available tools/equipment.
Functional capabilities.
Ease of use.
Compatibility.
Uptime/ reliability.</td></tr>
</table>

The main modifications we made to the performance measurement indicators include: 1) changing the terminology to healthcare terms, 2) making sure the patient safety indicators are included, and 3) adding new indicators that we observed and identified in our analysis. The specific healthcare term modifications are healthcare providers, patients' experience of care, continuity of care, and individual treatment plans. The additional patient safety indicators include health information security and patient safety issues.

Based on our analysis, we added the following new indicators: standardization in structure and content of information, available guidelines/procedures (formal/informal), available protocols/checklists, form of information (verbal, written, or other forms), consistency in methods and tools for exchanging information, formal/informal responsibility, and the practice of and standardization of formal routines.

8 Conclusion

We found that the work system framework accommodated the comprehensive systems analysis needed for a healthcare setting. With this study, we make three contributions to the literature. First, we demonstrate how one can use Alter's (2013) socio-technical framework for systems analysis to evaluate the exchange of health information that occurs when patients transfer from nursing homes or home healthcare services to a hospital setting. Second, we present a template with recommended improvements to the work systems that we analyze related to the six central elements of the WSF. Third, as a result of our study, we present a modified work system snapshot template for examining healthcare information exchange. The modifications include: 1) changing the terminology to healthcare terms, 2) including patient safety indicators, and 3) adding new indicators that we identified in our study.

Overall, we found that the WSF was useful in identifying areas to improve in exchanging health information. As with any research, our study has limitations. First, we focused on two counties in Norway; therefore, one cannot generalize the results. However, we hope this research provides inspiration for the importance of using a socio-technical approach in healthcare settings. Future research should focus on validating the proposed healthcare performance-measurement indicators and evaluating the "to be" modifications proposed in the health information exchange process.

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Appendix A: Elements of the Work System Framework

Table A1. Elements of the Work System Framework

Elements	Definition
Processes and activities (work practices)	Work practices include all of the work-related activities in the work system that occur when participants produce products and services for its customers.
Participants	Participants are people who perform the work-related processes and activities in the work system. Participants include both users and non-users of information technology (IT).
Information	Information includes the information that is used, created, manipulated, stored, transferred, and so on during work-related processes and activities. Information incorporates codified information such as standardized or predefined information and non-codified information such as computerized or handwritten documents, verbal agreements, and formal or informal conversations. One can also view participants' knowledge as a special case of information.
Technologies	Technologies are tools that help participants work more efficiently and may include cell phones, fax machines, and hardware/software such as different computer applications and computers.
Products/services	Products and services are information, actions, and/or services produced in the work system for the benefit and use of its various customers.
Customers	Customers are internal and external individuals or organizations who receive, use, or benefit directly from the products and services that are produced in a work system.
Environment	The organizational, cultural, competitive, technical, demographic, and regulatory environments in which the work system operates comprises factors that may have direct or indirect impacts on the work systems performance.
Infrastructure	Infrastructure includes relevant human, information, and technical resources that are essential to a work system's operation but are managed outside of it and shared with other work systems.
Strategies	Strategies are different levels of guiding rationale and high-level choices of design and operations of a work system or organization.

Appendix B: Work System Snapshot (Template) (Alter, 2006)

Table B1. Work System Snapshot (Template)

Customers	Products and services	
*	*	
*	*	
*	*	
Major activities or processes		
*		
*		
*		
*		
*		
Participants	**Information**	**Technologies**
*	*	*
*	*	*
*	*	*

Appendix C: Survey Questionnaire

1. In which county do you work?

◯ A ◯ B

2. In which part of the municipality based care do you work?

◯ Home Health Care Services ◯ Nursing Homes

3. For how long time have you been working as a nurse?

◯ 0-5 years ◯ 6-10 years ◯ 11-15 years ◯ 16-20 years ◯ more than 20 years

4. For how long time have you been working in this workplace?

◯ 0-3 years ◯ 4-7 years ◯ 8-11 years ◯ 12-15 years ◯ 16-19 years ◯ more than 20 years

Based on how the hospital discharge is done at your workplace please, put an X in the box that contains the information that best describe how a hospital discharge/information exchange is done.

	Timeframe	Never	Seldom	Now and then	Often	Always
5.	The information is given by the patient's home / institution when the patient is admitted.					
6.	The information is forwarded when the patient is transferred to the hospital.					
	How often do you use the following method / tool for information exchange on acute admissions to hospital?	**Never**	**Seldom**	**Now and then**	**Often**	**Always**
7.	The information is sent from the patient's home / institution in an envelope.					
8.	The information is sent from the patient's home / institution in an envelope with a checklist.					
9.	Fax					
10.	Regular email					
11.	Electronic link directly to the hospital (via The Norwegian Health Network)					
12.	Personal digital assistant (PDA)					
13.	Phone					
	How often do the following forms of information exchange take place?	**Never**	**Seldom**	**Now and then**	**Often**	**Always**
14.	Giving verbal information to emergency medical / ambulance personnel, so that the necessary information is listed in the admission note.					
15.	Sending the pill box with accompanying medicine list or multi-dose containers.					
16.	Sending a copy of the medical record from a GP.					
17.	Sending a copy of the medical record / daily notes from the nurses.					

18.	Sending a hand-written admission note (or copy).					
19.	Sending a copy of the user card / patient card.					
20.	Sending a copy of the medication list / medication card.					
How often have the information that is exchanged the following structure?		**Never**	**Seldom**	**Now and then**	**Often**	**Always**
21.	Handwritten admission note; unstructured in free text format.					
22.	Handwritten admission note; structured after predefined areas.					
23.	Electronic admission note; unstructured in free text format.					
24.	Electronic admission note; structured after predefined areas.					
25.	Structured care plan / treatment plan for the patient.					
Requested information from the hospital		**Never**	**Seldom**	**Now and then**	**Often**	**Always**
26.	How often does your hospital call and request information from the nursing home / institution?					
27.	How often do you feel that the hospital has a different need for information than you have exchanged from your institution?					
Responsibility/control/safety		**Never**	**Seldom**	**Now and then**	**Often**	**Always**
28.	How often will other healthcare personnel than Registered Nurses take responsibility for admission / information exchange?					
29.	How often will checklist be used to see if the necessary information is sent with the patient?					
30.	How often will receipt be obtained from the hospital on the received envelope or the forwarded information?					
31.	How often does it happen that the information is astray?					
Guidelines/procedures/training				**Yes**	**No**	**Do not know**
32.	Did the current exchange of information with the hospital follow the internal formal policies / procedures?					
33.	Did the current exchange of information with the hospital follow the informal routines, which from experience is known by the staff?					
34.	Have you received training in the current guidelines at your workplace?					
35.	Have you received training in current practices at your workplace?					
36.	Are you familiar with your professional and legal responsibilities in relation to documentation and information in general?					

About the Authors

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Ann Fruhling (PhD, MBA) is a Mutual of Omaha Distinguished Professor of the College of Information Science and Technology and the founding Director of the School of Interdisciplinary Informatics at the University of Nebraska—Omaha. Her research focuses on evaluating and improving human-computer interaction efficiency and effectiveness in the healthcare domain. She has over 85 publications. Some of her research has appeared in *Journal of Management Information Systems, Communications of the AIS, Health Systems, International Journal of Medical Informatics, Applied Clinical Informatics, Advances in Management Information Systems, Journal of Information Technology and Theory Application, Journal of Computer Information Systems* and *International Journal of Electronic Health Care.* Since 2002, she has been the Principal Investigator of an emergency response system and bioterrorism surveillance system for public health laboratories called STATPack™ which is deployed in over 65 health laboratories across the Midwest.

Mariann Fossum (RN, MSc, PhD) is an Associate Professor at University of Agder (UiA). She has further education in ageing and elderly care nursing and received her master degree in nursing science with specialization in education from University of Oslo in 2000, and her PhD in Medical Science with specialization in Health and Caring Sciences from Örebro University, Sweden in 2012. She has over 12 years of experience in teaching nursing and health informatics to both graduate and undergraduate students at the Faculty of Health and Sport Sciences, UiA, Norway. As a part of her duties, she has supervised master students and has been responsible for leading research projects. Most of her research has been conducted in the area of nursing and health informatics, and in particular, decision-making and information technology used in healthcare. As a registered nurse, she has experience from hospital and home healthcare services in Norway.