FROM ADMISSION TO DISCHARGE: INFORMATING PATIENT FLOW WITH “LIGHTWEIGHT IT”

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Abstract
In this paper, we investigate the role of IT in process innovation across functional boundaries from emergency unit to subsequent patient transfers in a complex organizational setting. The study explores the dynamics between traditional “heavyweight IT” and the emerging “lightweight IT” but conceptualize them as sociotechnical knowledge regimes which includes user-environments, knowledge domains and culture, in addition to the actual technology. We contribute by - drawing on Zuboffs notion of informating, and Kohli and Kettingers Three M’s messenger, messages and meeting - demonstrating how lightweight technology supported by a heavyweight infrastructure improves the organizational informating ability. Through systems that simplify digital interaction and which place heavier emphasis on visual display of information, as well as technological expertise that makes this kind of technology more readily available, lightweight technologies enables organizations to speed up and facilitate process innovation initiatives. A result lightweight technologies contributes in making information harvested from the heavyweight infrastructure more relevant across functional barriers.

Keywords: Heavyweight and lightweight IT, informating, process innovation.

1 INTRODUCTION

General hospitals have typically been structured to optimize specialists and departments work processes, while horizontal coordination has received less priority. This might become painfully clear to patients who suffer from ill-defined or interrelated health issues and are referred back and forth between seemingly uncoordinated professionals and departments for diagnosis and treatment. A common complaint from patients is thus that while the actual treatment was excellent, the coordination between units was slow, the waiting time long, and feedback almost nonexistent (Salazar et al. 2004, Norwegian Ministry of Health 2015). In Norway these challenges have informed the establishment of national coordination reforms, as it is “particularly important to ensure good coordination when the responsibility for the patient moves between hospitals and municipalities, and between departments and units within hospitals and municipalities” (Helsedirektoratet 2016).

In order to address coordination challenges that affect patient waiting time and health care expenditures, a number of initiatives have been implemented. Examples are patient logistics (Van Lent et al., 2012), clinical pathways (Rotter et al., 2010), and hospital supply chain management, which is a more systemic view of the flow of all types of resources (De Vries and Huisman, 2011). Hospital IT portfolios typically mirror hospitals emphasis on supporting clinical work processes rather than horizontal information sharing and coordination. Consequently, hospitals struggle to coordinate logistics both internally and externally (Van Lent et al 2012). This is of concern to hospital administrators as more efficient workflows across departments can save costs, enhance efficient use of scarce hospital resources (e.g., radiology), lead to more effective diagnosis and treatment of patients, and reduce patient waiting time (Devaraj, TTOw, R Kohli, 2013).

Efficient patient flow within hospitals relies on shared information of activities such as patient registration, patient prioritization, allocation of a doctor or nurse to the patient, ordering of lab tests and x-rays and booking of resources such as operating rooms and beds for patient surveillance. This, in turn, relies on information sharing between heterogeneous hospital information systems for patient admittance, nursing, laboratory, radiology, pharmacy, Electronic Patient Records (EPR), human resource and billing. Typically, these systems have been obtained from a multi-vendor market with a focus on resilience,
confidentiality and security, rather than efficient exchange of standardized information. In accordance with Bygstad (2016), we refer to these robust hospital information repositories and the IT engineering and support tradition that envelopes them as “Heavyweight IT”. However, to be able to leverage rapid developments in today’s IT industry and meet citizens growing expectations towards digitized health care services, hospitals and other health care institutions strive to implement “Lightweight IT” solutions, characterized by rapid implementation cycles, and ubiquitous access to tailored information through user-friendly interfaces (Bygstad 2016).

In this paper, following a process innovation initiative, we argue that lightweight IT can help informate across functional and professional boundaries in complex organizations such as general hospitals. We draw on Zuboffs notion informate, to denote processes whereby IT not only helps digitalize manual work, “but simultaneously generates information about the underlying productive and administrative processes through which an organization accomplishes its work.” (Zuboff 1988, p. 9-10)

We draw on this theoretical perspective to pose the question: How can lightweight IT informate across functional boundaries in organizations with a traditional heavyweight IT portfolio?

We operationalize our research through a case study at a new general hospital in Norway. Process innovation and improved coordination across functions has been an explicit strategy with the design of the hospital in general and around the emergency unit in particular. We specifically examine how Lightweight IT enable communication and information sharing to facilitate patient flow to, within, and from the hospital emergency unit.

2 DIGITAL INNOVATION AND LIGHTWEIGHT IT

Hospital IT portfolios typically constitute fragmented and clinically oriented IT acquisitions. These heterogeneous IT solutions are embedded in local practices and are often difficult to change for instance to support workflow process innovation and coordination. This is exacerbated by the fact that no single stakeholder has the oversight, capacity or decision making power to radically alter the complex status quo of such complex IT ensembles (Star and Ruhleder 1996; Hanseth and Lyytinen 2010). Although comprehensive and integrated EPRs have been proposed as a means for connecting heterogeneous systems in healthcare settings, they too have a tendency to become stagnant IT silos that sometimes curb innovation and fit badly with practice (Ash et al 2004, Berg 1999).

In general, digital technologies possess more innovative potential than their analog counterparts do (e.g., Sørensen, 2013; Tilson et al., 2010; Yoo et al., 2010), as digital services, applications and content can be reused and recombined and increase in breadth and value with the number of people involved in their production and consumption. Recently, we have seen a growth in digital services in tandem with individuals and organizations rapid uptake of commercially available devices such as tablets, smartphones, wearable sensors and electronic whiteboards. Bygstad (2016) refer to this as “lightweight IT”.

Lightweight IT is, however, not only the technology but also a sociotechnical knowledge regime with both independent and collaborative abilities. While the regime of lightweight IT are formed by the generative relationship between knowledgeable end-user groups and entrepreneurs, the heavyweight IT regime is dealing with core systems and the activities related to stabilizing, securing and scaling them (Bygstad 2016, Bygstad and Iden 2017). It follows that the two regimes have independent strengths. Examples of strengths with lightweight IT are mobile apps which enables swift purchase of metro tickets, apps to improve service work or white collar work as well as improved welfare technology solutions (Bygstad and Iden 2017). Heavyweight IT, on the other hand, enables secure access to comprehensive information repositories. Consequently, both are needed in order to enable profound business innovation (Bygstad 2016) and in our study, we are interested in the practical implications of this interplay, that is, how lightweight and heavyweight IT interaction supports “everyday” coordination within and across organizational departments and functions.

Recently, use of lightweight IT in healthcare with a traditional heavyweight IT profile has successfully improved organizational visibility of patient treatment statuses (Hertzum and Simonsen 2015; Hertzum
and Simonsen 2013; Aronsky et al 2008) and patient coordination (Wong et al 2009). Hence, lightweight IT may help facilitate coordination and process innovation by making information visible across functional boundaries. However, these studies are more concerned with the coordinative effects of whiteboard technology within a specific function or department. In our study we are interested in the potential for lightweight IT to extend extant (often rigid) vertical structures and Heavyweight IT portfolios to enable better coordination across departments.

3 INFORMATING ACROSS FUNCTIONAL BOUNDARIES

Davenport (1993) claims that handoff between functions are frequently uncoordinated in functionally oriented organizations. With reference to general hospitals, Mintzberg (1993, p. 56) claims that there are “interdependencies related to specialization, which favor functional grouping [...]”, even at the expense of workflow coordination”. He further argues that professional bureaucracies, such as general hospitals, typically lack well defined mechanisms for cross-functional workflow coordination and that this shortcoming is typically addressed by instilling coordinative roles. Coordinative roles generally lack direct formal authority over professional functions and structures, but may be endowed with social capital, managerial support and resources to negotiate coordination between them (Levina and Vaast, 2005).

Organization studies and information systems (IS) literature abounds with research on organizational roles that integrates and coordinates across “groups”, “tribes”, “clans”, “fields” or “communities of practice” by acting as “boundary spanners” (Lave and Wenger 1991; Carlile 2004; Cross and Parker 2004; Orlikowski 2002).

Star and Griesemer (1989) introduced the concept of boundary object referring to the broad range of technologies that “are plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites” (Star and Griesmer 1989, p. 393). Examples of boundary objects include prototypes (Bechky 2003; Carlile 2002), accounting ledgers (Briers and Chua 2001), and standardized reporting forms (Bowker and Star 1994; Star and Griesemer 1989). We are interested in how lightweight IT, as a broad class of boundary objects, can informate across functional boundaries in complex organizations, such as general hospitals, to enable better coordination and support process innovation.

We draw on Zuboffs (1988) notion informate to denote the use of IT to make information about work visible and actionable within and across organizational functions. Zuboff highlights the need for managers to recognize IT’s potential to generate information about productive and administrative processes that were previously opaque. She further argues that the organizational availability of information may set in motion a series of dynamics that will ultimately (re)configure the nature of work and social relationships that organize productive activity.

Kohli and Kettinger extend Zuboffs’ notion of informate in their study of an acute care hospital’s “attempts to exercise cost and outcome control over physicians via an information system by informing physicians' practice decisions with performance information” (Kohli and Kettinger, 2004, p. 364). The authors find that informing physicians’ work may be accomplished by “improving the recognized legitimacy of the information itself [the message], by employing boundary spanning messengers [human and/or technical], customizing user interfaces, and facilitating clan member discussion [through meetings]” (ibid, p. 365). In essence, messengers (boundary spanners, influential peer group members) help establish the information (or information system) as legitimate, while management's facilitation of discussions (e.g., through meeting support) can assist professionals’ adaptation and adjustment to the newly introduced information in practice. Hence, hospital management can indirectly influence clinical practice in closer congruence with its goals by informing through the “Three M's” (message, messengers, and meetings). Finally, although the study concerns the informating of one relatively autonomous group of hospital professionals, the authors observed that informating takes place through influence relationships both across organizational groups (boundary spanners and physicians) and within groups (chief,
persuasive peer, inspirational peer, friend, etc.). In our study we draw on Kohli and Kettingers elaboration of the informing concept to explore informing dynamics specifically across hospital groups and functions.

In summary, we understand informing as the organizational sharing and use of information enabled by digitization of manual processes and (re)combination of extant digital information. The resulting transparency regarding organizational activities, processes and resources may allow managers, process coordinators and groups of professionals to arrive at tactics to improve organizational performance. However, process innovation, facilitated by leveraging the organization’s informing potential, may result in both desirable and undesirable adjustments. Information generated at one place can generate unintended adjustments elsewhere (Perrow 1999, Garud and Kumaraswamy 2005). We are interested in understanding how lightweight IT can interplay with heavyweight IT and improve cross functional coordination without jeopardizing often delicate (clinical) processes.

4 METHOD

The setting for our empirical research is Kalnes general hospital in Østfold county (near Oslo) in Norway. Østfold has about 300,000 inhabitants. The 85,500 square meter yellow and beige hospital in Danish design opened in November 2015 and replaced the old Fredrikstad hospital. Kalnes has one of Norway’s largest emergency units in addition to general hospital functions such as delivery wards, clinical and surgical wards and psychiatry. At the old hospital in Fredrikstad, wards were distributed across different buildings with up to nine floors based on functional separation. At Kalnes the hospital design is markedly different. The hospital has four floors and the building has been designed to allow different departments to expand and retract.

The construction of Kalnes hospital has created an opportunity for hospital-wide process (re)design. Mobile technology and electronic whiteboards are deployed all over the hospital. The electronic whiteboards provide up to date information for (waiting) patients, their families, clinical professionals assigned to patients and hospital support staff. The hospital management has high ambitions regarding its process oriented use of IT (Bygstad et al 2017).

Our case study research approach is based on engaged scholarship (Mathiassen 2017) where informants are not only sources of empirical data, but also helpful in constructing narratives and discuss theoretical and practical implications (Bygstad and Munkvold 2010). Hence, research becomes a collaborative endeavor between researchers and practitioners that together refine research findings (Mathiassen 2017, Bygstad and Munkvold 2010). One of the authors of this paper was central in the process of planning and implementing the IT solutions at Kalnes. The planning included redesign of the old workflow processes at Fredrikstad, as well as organizational restructuring. The planning phase included tight interaction with the providers of digital whiteboards and mobile technologies as well as identification of integration points with the extant IT portfolio.

4.1 Data Collection

From July 2016 to April 2017, we conducted 25 interviews, with clinicians, project leaders, technical experts and cleaning personnel. In order to study IT solutions in use we had four rounds of observations (22 hours) over a period of two months. We followed up with new interviews as well as analyses.
of documents on patient treatment regulations, political requirements from the regional health authorities as well as descriptions of the technical solution. We were also invited to, and participated in, local and regional meetings and workshops where findings, including ours, were discussed.

Our data collection (table 1) started with interviews and talks where Kalnes management and project leaders presented the main goals as well as the organizing of the IT oriented process innovation initiative. We then performed observations within the emergency unit and the health wards, where process flow challenges was seen as substantial. Through this “bottom-up-investigation” we identified coordinative actors, actors whose central role is to plan and coordinate the movement of patients and information across hospital departments, and were particularly interested in how they use IT to perform and coordinate their work.

<table>
<thead>
<tr>
<th>Activity and Description</th>
<th>Participants</th>
<th>Outcome</th>
</tr>
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<tbody>
<tr>
<td>3 initial interviews, then 22 “follow-up” interviews in order to elaborate.</td>
<td>Part 1: Research manager, CTO, project managers. Part 2: System supplier, Project manager, nurses, clinicians, secretaries, ward managers, coordination nurses, cleaning personnel</td>
<td>Understanding the main goals of the project, getting necessary access. Clarifications and elaborations. Insight into architectural and structural aspect of whiteboard technology.</td>
</tr>
<tr>
<td>4 whole day session observations</td>
<td>Emergency unit, lung department, neurology department</td>
<td>Insight into the everyday practices and use of technology. Role of electronic whiteboards and mobile in coordination practices.</td>
</tr>
<tr>
<td>3 meetings, 1 workshop</td>
<td>Health-South East program managers and project leaders, clinicians, CTO, CEO</td>
<td>The role of Kalnes in the regional strategies, i.e the project as a part of coordination improvements regionally.</td>
</tr>
<tr>
<td>Analyzing documents written by Østfold ICT and Health Southeast authorities. Design document from system supplier</td>
<td>Strategy documents, design documents, role descriptions</td>
<td>The role of Kalnes in the regional strategies.</td>
</tr>
</tbody>
</table>

Table 1. Data collection

4.2 Data Analysis

Our initial data analysis (step 1 in Table 2) was informed by two themes: The identification of opportunities and challenges for assisting process oriented re-design of hospital patient flows with digital ICTs and the role of ICTs in mitigating emergent process bottlenecks. For instance, mobiles and whiteboard technology availed information about the status of patients and resources such as rooms and beds across hospital functions in real time. However, this seamless information transparency could sometimes introduce new coordination challenges, such as when predefined status updates for resources (e.g., rooms and hospital beds) did not correspond with actual situations. We analyzed the case in the light of how interplay between technological components enable or constrain work performance of coordinative actors, and were particularly interested in the gradual improvements obtained through collaboration.

In step 2, we applied the lens of the 3 M’s (messages, messengers and meetings) and informing to consider how the interplay between heavyweight and lightweight IT allowed for iterations of process
innovation within and across hospital functions who needed to coordinate in action. Finally in step 3 we theorized the role of lightweight IT in digital innovation.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Output</th>
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<tbody>
<tr>
<td>1</td>
<td>Identify key coordinative actors and their challenges regarding process flow, as well as the key technology for supporting process flow. Identify situations where (digital) ICTs mitigate or exacerbate patient flow bottlenecks, and examine the interplay between heavy-weight and lightweight technology in sharing the status of resources faster and to more relevant decision makers.</td>
<td>Section 5: Case description, three aspects of workflow challenges during process innovation: Digitalization, informing and self management</td>
</tr>
<tr>
<td>2</td>
<td>Analyze the process innovation challenges in the light of the three M’s, messages, messengers and meetings (Kohli and Kettinger 2004), to generalize our findings.</td>
<td>Section 6: Digitalized interaction, cross-functional transparency and self-management.</td>
</tr>
<tr>
<td>3</td>
<td>Theorizing role of lightweight technology in digital innovation</td>
<td>Section 7: Discussion</td>
</tr>
</tbody>
</table>

Table 2. Data analyses

5 CASE AND FINDINGS

Kalnes hospital had several process challenges, for example (from Bygstad et al 2017, p. 806):

- “Receiving emergency patients arriving with ambulances or by taxi, registering them, conducting triage and medical diagnoses, and requiring additional services such as lab tests or radiology.
- Allocating new hospitalised patient to wards and beds, and providing the necessary information to the staff, and to patient’s family.
- Coordinating the discharge of patients with municipalities. For instance, the municipal care institutions required that information on an incoming patient should be sent before noon.
- Providing the cleaning department with timely information on which rooms to clean, and when.”

The process innovation activities went through three phases (1) piloting at old hospital, (2) implementation at new hospital and (3) stabilizing of solutions (Bygstad et al 2017). In our study we build on these findings but elaborate on the second and third point, primarily because we are interested in the workplace consequences of process innovation initiatives. The hospitals are struggling with slow process flow across functional departments, but also with being able to measure coordination within and between work processes. A broad range of manual routines makes overview across functional departments challenging. The ability to quantify performance improves overview. Digitalization efforts must, however, start somewhere, and will run into challenging situations. Digitalization is nevertheless important to reach the goals of the coordination reform.

Between 90 and 120 patients, arrive at the emergency unit at Kalnes general hospital every day. Some arrive by helicopter or ambulance, but most patients “drop in”. Drop in patients have been referred by their general practitioners or primary health care units, or they come directly with help from friends or family members. Kalnes hospital has a stated efficiency goal that patients should not stay for more than two hours at the emergency unit patient admis-

Figure 2. Emergency unit control board
Kalnes hospital has several wards (e.g., neurology, heart and lung wards) positioned in close proximity to the emergency unit, where emergency patients can stay up to three nights. Each department has a coordinative nurse tasked with facilitating patient flow. To support coordination, Kalnes hospital has acquired standard electronic whiteboards and mobile devices with proprietary IMATIS software. For instance, the IMATIS organization have cooperated closely with Kalnes hospital both during implementation and in activities related to improving and tailoring the solution according to Kalnes’ needs. An internal project manager emphasize this: “It is very interesting to work with them…they are very active and interested in how we are doing.” The EPR provider does not ignore the creativity from Kalnes, but often respond with, “yes, this is a good idea, but you have to wait for our next upgrade.” The project manager says, “IMATIS [organization] have understood that the development is happening here and now, not in 2 or 3 years.” IMATIS software was configured to integrate data from Electronic Patient Records (EPR), radiology, lab, human resource, housekeeping and nurse call. Whiteboards with IMATIS software are installed in all hospital departments, including the emergency unit. Hospital staff, regardless of function (e.g., nurse, clinician or housekeeper), can access custom IMATIS views on mobile clients (tablets and smartphones), and whiteboards, based on their role and location within the hospital. Figure 3 is a simplified description of the solution at Kalnes, where lightweight IT operates as a front-end, integrated with the heavyweight infrastructure through a integration interface. It is also a general visualization of a possible relation between lightweight and heavyweight technology in process innovation.

**Figure 3: Overview system configuration lightweight and heavyweight**

We continue by describing three aspects of process innovation: digitalization (5.1), and some organizational effects of digitalized processes (5.2 and 5.3). While 5.2 focuses on the effect of integration between front-end lightweight technology and back-end heavyweight infrastructure, 5.3 is obtained with the increased self-management this contributes to.

### 5.1 Digitalization: Coordinating workflows with whiteboards and mobiles

At the previous hospital in Fredrikstad, the process of identifying available resources (e.g. rooms, equipment and personnel) was often manual. Nurses would walk around, ask colleagues, and then make notes on the availability of resources. At Kalnes resources are registered electronically and given a status to indicate their availability. There is functionality in IMATIS to display available rooms across departments and reserve them for patients. Although bookings could be made through IMATIS directly, the general rule is that any booking should involve a phone call to the department’s coordinative nurse.
The identification of resources and their status enables the hospital to share resources across functions and wards. A nurse pointed out that the whiteboard system “is important in the administration of the unit […] Earlier we had to call for every detail, now we have a much better overview”. Another nurse indicated that “it is much easier to get an overview when we not only have the information in our heads but also on the screens.” Similarly, a clinician emphasizes the visual overview capabilities:

“IMATIS gives good overview, also when patients family are calling it is easy to respond. It gives good communication with catering and housekeeping. In addition, it gives good overview of who is admitted to the department and what department they belong to.”

When a patient is transferred from the emergency unit to an adjacent department, there are a number of checks to be performed and communicated. First, the doctor assigned to the patient gives the emergency unit coordinator the task of finding a room for the patient. The coordinator then registers in IMATIS that the patient is “ready for ward”. The receiving ward considers this request and responds. The status of the patient is then updated to “reported to post”. The coordinative nurse in the receiving ward identifies a room for the patient and send a message to the hospital porter who makes sure that a bed is in place. Finally, a report about the patient transfer is sent from the emergency unit to the ward. A clinician comments on the procedure and indicates that “our goal is a ‘silent report’, but some of the coordinative steps are still done by phone.”

The following example narrative, documented by the emergency unit as part of their internal workflow assessment, illustrates this point:

The emergency unit applies to transfer a patient to the heart ward. The heart ward is full, but they have two patients who can be transferred to the lung ward. The heart ward coordinator calls the lung ward which responds that they have no available beds. This is not reported back to the emergency unit. The patient is still marked “ready for ward” in IMATIS. The emergency unit calls the heart ward again, only to receive the response that neither of the wards have available beds. However, the coordinator at the emergency unit knows that the lung ward has unused space in the corridor (not captured in IMATIS). The emergency unit then continues to enforce the move of patients from the heart ward to the lung ward so that the emergency unit patient can transfer to the heart ward six hours after the first inquiry. The transparent access to information about hospital resources in a standardized format is here contradicted by peoples’ tacit knowledge of local practices. Despite their widespread use, corridor beds are not accessible through the booking procedure in IMATIS.

Also the housekeeping department are integrated into the process innovation initiatives at Kalnes. As a general rule, hospital rooms are cleaned whenever a patient is transferred or discharged. At the old hospital in Fredrikstad, ad-hoc communication had to take place in order to identify when room cleaning should be performed. At Kalnes, the identification of resources in IMATIS allows nurses to register when a room requires cleaning. Housekeepers also make status updates in IMATIS by indicating that “cleaning is in progress” and “cleaning is finished”. According to a coordinative nurse at the emergency unit: “the cleaning routines itself takes about 30 minutes, but sometimes it takes three hours from a room is booked for cleaning until the cleaning is performed, especially during peak hours”.

With IMATIS, an often overlooked support function at a general hospital, such as housekeeping, have become more visible. The housekeeping department's impact on patients' length of admittance, the number of corridor patients and the patient waiting time have been quantified, to some extent. This information transparency puts pressure on the housekeeping department to address performance issues. However, local autonomy allows housekeeping to address these challenges within their own department based on available human and financial resources.

5.2 Transparency: Accessing integrated information through custom user views

A large portion of the information displayed through IMATIS on mobile devices and whiteboards are retrieved from the main Electronic Patient Record (EPR) system at Kalnes, called DIPS. The interplay between the EPR, the whiteboard technology and other major hospital information systems such as human resources provides a rich repository of data for recombination and innovative analysis of cross-
functional flow processes. Generally, digitalization, where manual information-processing work between the source and the registration are removed or reduced, have improved significantly the possibilities for displaying transparent information all over the hospital. This makes it easier for management, department managers and coordinative actors, as well as clinicians, to discuss workflow challenges. For instance, Figure 2 from the emergency control center demonstrates the monitoring ability enabled by digitalization. The nurse have overview of all needed information from the whiteboard, the patient record as well as the ambulance system. This enable her to proactively plan the patient treatment and map the necessary resources onto the patient trajectory.

An important prerequisite for process innovation, however, is that (clinical) processes can be divided into sub processes that can be measured and communicated. An example of this is triage. At the admission point of the emergency unit, triage is performed in order to decide the level of emergency on incoming patients. Triage comes from the French word “trier” which means “prioritizing” or “sorting”. The purpose of triage is to ensure that patients with the most urgent needs for emergency care will receive it first. However, as one process architect at Kalnes argues:

“Capturing data about clinical sub-processes and resources is a challenge. When clinicians are asked to measure the process of triage they perform and measure the entire treatment, not only the identification of what treatment is needed. While the process of triage is quick – around 2 minutes - the treatment takes a long time, sometimes up to an hour.”

This discrepancy is caused by the clinicians’ ability to quickly assess who needs treatment first, and then complete the treatment, without making any registrations in between these steps. However, a clearer separation of triage and treatment and associated data capture could potentially lead to more timely and efficient mapping of hospital resources to the patient. Currently, IMATIS gives an overview of patients with their reason for admission, the level of emergency (triage), the result of blood tests and x-ray results as well as an indication of who is the responsible nurse or doctor. This visibility, which relies largely on the integration between IMATIS and DIPS (through the integration interface, figure 3), keeps clinicians and support personnel informed and enables swift adjustments.

However, the integration between IMATIS and DIPS have also created challenges in terms of keeping users informed about where data actually resides and how information is shared and updated between systems. For instance, as indicated by one housekeeper:

“some coordinative nurses delay the booking of room cleaning for patients who are targeted for transfer or discharge as they are worried information registered in IMATIS will feed back into DIPS where the status of the patient has not yet been updated by the clinician in charge of the patient”.

For this particular data, the synchronization between DIPS and IMATIS is one way only, from DIPS to IMATIS, but this is not evident from the IMATIS interface. As a number of hospital information systems have been integrated through IMATIS, the in-house IT department struggles to communicate the IT architecture to end users who mostly see the information through one integrated user interface. This has also caused challenges in making users aware of what pieces of information they may need to remember between IMATIS views if one of the integrated systems goes down or become irresponsive. It is therefore not always clear to practitioners what implications one system’s breakdown will have at different stages of workflow coordination.

A major precondition for interplay between mobile and whiteboard technology and the patient record systems is the existence of interfaces the different systems can use for interaction. Kalnes have together with the major system providers of EPR and IMATIS technology established an interface which grants access to major information systems through a RPS (Resource and process management system) interface (Figure 3). This interface both facilitates innovation and digitalization, in that it gives access to information across system domains. As the two systems are integrated with the personnel administration system called GAT, there is a rich repository of information available for customization and adaptation to different user needs.
5.3 Self-management: Enabling workflow process innovations

As we noted above, standardized division of clinical processes into sub-processes is a precondition for cross functional transparency if the information is to be understood and interpreted correctly across units. In response to efficiency challenges and based on data reports from IMATIS the housekeeping department has reorganized their team compositions and rescheduled their working hours and shifts two times during the year 2016 alone. Furthermore, the housekeeping department has been able to draw on information from IMATIS to document how their own performance is influenced by nurses and clinicians’ erroneous requests for cleaning the wrong rooms, at wrong times, or with wrong priority settings. In turn this information has helped the housekeeping department to argue for a seat at the hospital’s weekly process coordination meetings. Before their influence on horizontal process flow was made visible throughout the hospital, the participation of the housekeeping department and other support functions in these coordinative meetings had not been deemed relevant.

The gradual digitization of flow processes has been strengthened by the creation of arenas for discussing and negotiating the meaning of information regarding patient flow. An example is the whiteboard morning meeting where the focus is on day-to-day coordination and patient logistics. A central challenge at Kalnes is the mid-day “peak hours” when both the emergency unit and the wards are full. One remedy is to discharge patients from wards in the morning so that beds are available by mid-day. The hospital process coordinator reflects on the use of morning meetings:

“The whiteboard meeting starts at 08:50, and lasts for ten minutes. In this meeting, all the admitted patients are discussed as the participants try to identify who can be discharged. The unit manager is managing the whiteboard registrations, while the doctors and nurses give feedback. The patients are then divided into three categories: those who need immediate help, patients who can be discharged, and patients who should stay another day. This practice [the morning meetings] also enables the cleaning personnel to get a good insight into which rooms have to be cleaned during the day.”

The decisions taken in the morning meetings are implemented immediately by touching the whiteboard screen and changing patient statuses.

During autumn 2016, weekly Friday meetings, called “patient flow seminars”, were established by the hospital process director to address general resource challenges such as availability of hospital beds. At these meetings, different departments prepare narratives based on information from IMATIS that illustrate workflow coordination challenges which impact hospital performance on patient waiting time, number of corridor patients and length of patient stay in the hospital. Through lightweight IT Kalnes have increased its ability to identify bottlenecks and discuss and negotiate solutions, such as assigning hospital staff to different departments based on dynamic demands. The patient flow seminars bring together coordinative roles, clinicians and support staff across departments to strengthen the collective insight into different functions’ processes and their cross functional interdependencies.

6. ANALYSES: INFORMATING WITH LIGHTWEIGHT IT

In this part, we will analyze our empirical data outlined in the last chapter. Table 3 (below) column 1 and column 2 summarize the empirical section, while column 3 repeats the most important aspects of the theoretical lens. Column 4 outlines the outcome of the analyses, and will be discussed in this section.

In general, The Three M’s (Kohli and Kettinger 2004) are helping complex and structured organizations improving their informating ability. We will discuss how lightweight IT (IMATIS) interplay with heavyweight IT (EPR) to facilitates process innovation by (1) supporting coordinative roles, (2) integrating data and provide custom information views to relevant groups who need to coordinate activities, and (3) serving as a shared information platform for coordination and process innovation involving different hospital functions. We will do this in four sections listed in column 4.
**Empirical section**

**Findings**

**Lens: Informate through the three Ms**

**Outcome**

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### Coordinating workflows with whiteboards and mobiles

| Transition from manual to digital identification of resources, and the efforts in obtaining this. | **Messengers (M1)**; the presence of messengers (i.e., boundary spanners) who help legitimize the information captured and shared through IT | (1) Digitalized interaction between coordinating roles and technological infrastructure (M1 and M2) |
| Improved overview and easier sharing of information. | | |
| Distributed access enables self-organization. | | |
| Potential errors caused by universal access to local resources. | | |

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### Accessing integrated information through custom user views

| Rich amount of information from EPR and HR system, gives A rich repository for data recombination Challenges with sub-process optimization and cross-functional transparency | **Messages (M2)**; the availability of custom information views to different groups | (2) Cross-functional transparency through lightweight and heavyweight IT (M2, M1, M3) |

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### Enabling workflow process innovations

| Informed arenas for discussing possible solutions for solving common challenges, both local level and at hospital level | **Meetings (M3)**; the conduct of meetings where information and its implications for practice are discussed and negotiated | (3) Informating local functions’ self-management (M3, M1, M2) |

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**Table 3. Result of analyses**

**6.1 Digitalized interaction between coordinating roles and digital infrastructure**

According to Hertzum and Simonsen (2015, 21) “whiteboards facilitate coordinative practices by making information publicly accessible and thereby strengthening communication and joint commitment about it”. In relation to use of whiteboard technology within and around an emergency unit in particular, Aronsky et al (2008, 192) note that the transparency of cross functional information about patient flow “optimize information management, and maximize effective communication within and outside” the unit.

The work of coordinative actors (messengers or boundary spanners) are important both as a “glue” bridging cross-functional processes, and as an actor highlighting the need for taking action when bottlenecks threaten the cross functional workflow. Their roles, which are inherently non-authoritative, are strengthened both through the visualization of flow challenges with lightweight IT, and through the establishment of arenas where flow challenges may be discussed and addressed. Through daily morning meetings and weekly patient flow seminars, department coordinators and representatives of the different hospital functions are able to reach compromises based on shared insights into local procedures and challenges. These established arenas for addressing workflow bottlenecks also helps legitimize the hospitals focus on horizontal process innovation and has allowed management thinking to seep into vertical functions’ processes. Lightweight IT, as a customizable boundary object, has allowed functional groups at Kalnes to monitor their own performance, their influence on the performance of other groups and the organization as a whole. Informating with lightweight IT also allow functional groups to monitor the performance effects of their own process innovations. This provides an incentive to experiment and improve.
6.2 Cross-functional transparency through lightweight and heavyweight IT

At Kalnes, we find that a central premise for process innovation, is the interplay between heavyweight and lightweight IT (figure 3). The interplay enables informing dynamics, and cross functional sharing of process information. The premise for this is to avoid the displaying of overwhelming amount of data that thwarts efficient decision making. The implementation of cross-functional processes requires configuration of departments’ and hospital functions’ internal processes in a way that aligns clinical and horizontal workflows.

However, we also see that there are limitations to how granular specialist processes can be divided and measured for the sake of cross functional process coordination. The clinical process of triage and the subsequent treatment, for instance, have proven difficult to quantify, as different clinicians approach data capture concerning this procedure in different ways in different clinical situations. Despite imperfect information, the IMATIS views (the technical messenger) enable the display of patient information in such a way that it supports communication and coordination regarding flow challenges in real time. Clinical information is a fundamental prerequisite for this coordination as it is mapped onto the horizontal workflow trajectory to support coordination. Although lightweight IT is vital in visualizing horizontal workflows, integration with the heavyweight clinical IT systems are central in making this visualization possible.

6.3 Informating local functions’ self-management

At Kalnes improved availability of information, and the ability to display it through customized views, enables departments to manage and adjust their functional processes to mitigate workflow challenges across functions. For example, the housekeeping department has been able to re-organize their activities based on actual hospital needs during “peak hours”; ward managers organize their units based on analysis of patterns of referral, treatment and discharge, while different department’s coordinative roles identify available hospital resources and map them onto their patient trajectories. This does however have the potential to contradict departments’ autonomy in managing access to their local resources. In particular, long-term hospital wide resource planning, based on information generated through lightweight IT may enforce too rigid planning requirements on local departments who need to maintain local flexibility. Furthermore, local management of resources could be difficult to represent in a standardized way across functions, as illustrated by our example from Kalnes with the widespread use of corridor beds.

Tight integration between heavyweight and lightweight IT systems may create situations and ripple effects where a system error in one place causes unintended or unexpected results in other connected systems. This may be particularly problematic when systems are so well integrated that end users no longer are able to assess what system they are making data capture against or retrieving information from – as everything is seamlessly “at their fingertips” in one user interface. For instance, it may be challenging to understand what information the user may need to commit to his or her memory in order to complete a process when one of the underlying sources of data are not functioning as expected.

7. DISCUSSION

We return to our research question: How can lightweight IT informate across functional boundaries in organizations with a traditional heavyweight IT portfolio?

Our study has both practical and theoretical implications. Our practical contribution regards the role of modern innovative technology in improving coordination challenges at complex and functionally structured organizations such as general hospitals. As the clinical orientation with interdependencies related to specialization leads to functional rather than horizontal optimization, establishing coordinative and cross-functional workflows are challenging but increasingly in demand. In healthcare, this is important in order to optimize capacity and resource utilization and decrease patient waiting time. Earlier research on the use of lightweight IT to support cooperative work (Hertzum and Simonsen 2015; Hertzum and Simonsen 2013; Aronsky et al 2008) and patient workflow (Wong et al 2009) have mainly concentrated
on the endeavors in improving coordination within wards, such as emergency units. We add to this stream of research by providing some insights and challenges in obtaining cross-functional coordination from admission to discharge.

Whiteboards and Mobiles – integrated with EPR and HR systems – becomes an important ally in coordinative actor’s orchestration of cross-functional processes. This regards the visualization of patient flow statuses regarding admission, treatment and discharge, as well as the improved overview, and facilitated use of resources. Lightweight IT systems are also an allied during the establishment and arrangement of meetings where coordinative challenges are discussed, bottlenecks are addressed and solutions are agreed on. Also the housekeeping department are integrated into the process innovation initiatives at Kalnes.

Lightweight technology as a process innovation knowledge regime
- Improves an organizations informing ability
- Enables digitalized interaction
- Easier to identify bottlenecks
- Increased redesign flexibility
- Enables distributed autonomy
- Loosely coupled architecture

**Figure 4: Process innovation and lightweight technology**

Our theoretical contribution (figure 4 gives a overview) of lightweight IT as a process innovation knowledge regime, first relates to the three M’s, messages, messengers, meetings (Kohli and Kettinger 2004). Kohli and Kettinger (2004) build on Zuboff (1988) in identifying some practical organizational prerequisites for achieving improved informing ability. We build on the Three M’s in demonstrating how lightweight technology facilitates the booking of digital resources (messages), how coordinative actors enables and are enabled by the technology in providing more efficient patient flow (messengers), and how arenas for informed discussion where decisions may be taken and registered right away, are established (meetings). Lightweight technology is thus important in providing digitalized messaging between clinical and coordinative actors, as well as important in its ability to display patient information in a way that facilitates discourse on flow challenges. This interest does however not go on behalf of clinical information. Although the lightweight technology is central in visualizing the status in relation to the horizontal flow, the clinical systems are a central source in enabling this visualization. The coordinative actors are important both as a “glue” bridging cross-functional processes, and as actors highlighting the need for taking action when bottlenecks threaten the flow. We add to Kohli and Kettinger by demonstrating the ability of a socio-technical knowledge regime – lightweight technology – to take good use of the three M’s.

Second, along the same lines, we demonstrate how lightweight technology enables the establishment of digitalized relations across distance (Yoo et al 2010). Relating to the field of digital innovation (Tilson et al 2010, Yoo et al 2010, Henfridsson et al 2014) we extend our understanding of the new dynamics of digital applications, services and content. The informing capacity of lightweight technology is strengthened by an increased redesign flexibility (Henfridsson et al 2014). The redesign flexibility is
significant also because the lightweight system supplier is very active in maintaining and improving the installation and the functionality. In addition, digital equipment aligned with coordinative actors enables distributed autonomy and management (Tilson et al 2010). The innovative technology gives organizational actors a view where they can monitor their own performance, and the effects of their own interventions. This allows the actors to change, experiment and improve. It also gives actors insight into their position in the bigger system, and hence inspires “double-loop learning”, and changed control paradigms (Tilson et al 2010). The extended effect of this flexible interaction is an increasing capacity overview which improves capacity utilization. In addition clinical processes have long been provided with digital technology to register, identify and calculate patient conditions, while horizontal processes have suffered less attention. By using lightweight technology (easier to acquire, easier to adjust, faster implementation) as a front-end, loosely integrated with a heavyweight infrastructure (see figure 3) as a back-end, process innovation effort may be more successful (Bygstad et al 2017). The literature on heavyweight and lightweight IT (Bygstad 2016, Øvrelid and Bygstad 2016) fits within this stream, but have mainly been interested in understanding the innovative potentials generated from the interaction between heavyweight and lightweight IT. Our work demonstrates the process innovation capacity of lightweight technology through improved interaction enabling process efficiency.

Our findings does however, also give some warnings. Tight coupling between lightweight and heavyweight technology challenges both vertical and horizontal process stability when the operational core – the EPR system – stop working. Tight coupling may also lead to some “use-barriers” when the lightweight technology feeds back into the EPR core, opening up for negative side effects of user registration. An example here is when the housekeeping department have registration access which may affect the resource utilization at clinical wards.

In summary, we investigate the particular strengths of lightweight technology in process innovation initiatives. Its loosely coupled architecture enables process innovation initiatives to be planned separately and implemented faster. We relate this to lightweight technology being a knowledge regime (Bygstad 2016), with particular strengths that is brought forward in interplay with the heavyweight infrastructure.

8. REFERENCES


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