Enabling responsive hospital housekeeping with workflow IT

Authors: Terje A. Sanner, Egil Øvrelid, Department of Informatics, University of Oslo. Email: terjeasa@ifi.uio.no

Abstract

Workflow oriented use of IT in hospitals can increase resource utilization, patient satisfaction and patient throughput, by integrating and aligning work processes. However, the role of hospital support staff, such as porters and housekeepers in interdepartmental workflow coordination has received scant attention. With digitally integrated workflows, the influence of support services on patient flow becomes visible and open to scrutiny and explication. Empirically, we follow efforts to leverage IT to improve workflow coordination at Kalnes general hospital in Norway. Specifically, we employ the Theory of Swift and Even Flow to examine the influence workflow oriented use of IT has on housekeeping responsiveness to patient flow variability and temporary patient flow bottlenecks. We find that efforts to improve workflow coordination introduces novel ramifications for hospital housekeeping and that IT serves both as a real time coordinative tool and as a source for post hoc data analysis and process streamlining. In particular, we identify and discuss three maturity levels of IT mediated workflow coordination, which we refer to as workflow transparency, synchronization and responsiveness. We find that workflow oriented use of IT can raise the responsiveness of hospital support services through a combination of interdepartmental transparency and improved synchronization. Importantly, workflow integration can reveal interdependencies that impinge on the productivity of support staff but are beyond their immediate influence. Consequently, it is important to involve often-overlooked hospital support services directly in the planning and evaluation of workflow-oriented use of IT.

Keywords: Integration, workflow, IT, hospital housekeeping, Theory of Swift, Even Flow, patient flow

1 INTRODUCTION

Patient flow is a key indicator of process throughput and productivity in hospital operations (Litvak, 2010; Villa, Barbieri, & Lega, 2009). Patient flow bottlenecks associated with clinical and administrative tasks delay patient discharges and lead to lower healthcare quality and patient safety at higher costs. Prolonged patient stays in hospitals exposes patients to unnecessary risks of infection and medical complications. This is exacerbated by the fact that most general hospitals have a functional organizational structure (Mintzberg, 1993), whereby departments focus on their internal processes and costs and do not coordinate their activities with other departments involved in different steps of the same care processes (Drupsteen, van der Vaart, & Pieter van Donk, 2013; Lenz & Reichert, 2007). Hence, hospitals generally show a low degree of integration (Bamford & Griffin, 2008). To improve patient flow, hospitals have started to employ IT solutions that increase the cross-functional visibility of patient treatment statuses (Aronsky, Jones, Lanaghan, & Slovis, 2008; Hertzum & Simonsen, 2013, 2015) and support patient coordination (Wong, Caesar, Bandali, Agnew, & Abrams, 2009).

IT can assist in the preemptive planning of individual patient trajectories across hospital functions and wards by providing digital ques. The ability to adjust and revise plans across functions is particularly important at emergency unit hospitals where patient flow variability is high. As Sayah, Rogers, Devarajan, Kingsley-Rocker and Lobon (2014, p. 3) report from their study at an emergency unit: “We created a special status for these patients on our electronic ED tracking board and made it accessible to the hospital admitting service, the hospitalists, the residents, and nurses on the inpatient floors, housekeeping, and transport. This provided an early warning process to all stakeholders that could affect the flow of admitted patients and allowed the admitting service time to prepare and receive the admission”. Hospital support staff such as porters, housekeepers, food caterers and janitors are important, but often neglected, recipients of patient flow information. Accurate and timely sharing of patient flow information allows for efficient coordination between those who require support services and the personnel who perform them.

Hospital support services have often been overlooked in the design and implementation of coordinative IT solutions partly because the work is "diffused through the working process, partly due to the social status of those conducting it, and partly because it requires so much articulation work" (Star & Strauss, 1999, p. 21). This is problematic, because support services are critical to both the quality of health care services and their efficient delivery. Specifically, a hospital's housekeeping department is responsible for ensuring a high level of hygiene. This includes keeping bed rails, mattresses, taps, door handles and chairs sterilized and bacteria-free. Hospital housekeeping mitigate hospital-acquired infections and the spread of multi-resistant bacteria among hospital patients. In Norway, one in 20 hospital patients acquire at least one health service related infection. Furthermore, housekeeping can play an important role in improving patient flows through improved bed turnaround time, which contributes to efficient patient admission, transfers and discharge (Craven et al., 2006; McClelland et al., 2011; Wilson & Nguyen, 2004). Hence, the employment of IT to support the coordination of hospital housekeeping work is one promising venue to improve patient flow. We take this practical challenge as our starting point and pose the research question; how can workflow-oriented use of IT improve hospital housekeeping responsiveness to patient flow variability and mitigate temporary patient flow bottlenecks?

The remainder of the paper responds to the research question and is structured as follows. In the next section, we position our study in relation to relevant research on hospital workflow integration with IT. In section three, we present our analytical perspective based on the Theory of Swift and Even Flow, which holds that the more swift and even the flow of materials (or information) through a process, the more productive that process will be (Schmenner & Swink, 1998). In section four, we detail the operationalization of the research through a case study of IT mediated workflow coordination at Kalnes hospital in Norway. We selected Kalnes hospital due to the hospital managements' explicit aim to improve patient flows through process innovation as well as its determination to leverage novel IT, such as electronic whiteboards and smartphones, to this end. In section five, we analyze how workflow oriented use of IT has helped Kalnes hospital in general and the housekeeping department in particular in its implementation of performance enhancing revisions. Finally, in section six we discuss how a broad and inclusive approach to data analysis and planning of measures to improve patient flow, with the housekeeping department directly involved in interdepartmental coordinative meetings, has allowed Kalnes hospital to realize the potential benefits of workflow oriented use of IT.

2 INTEGRATING HOSPITAL WORKFLOWS WITH IT

Integration has been explored previously from an information systems perspective (see e.g., Ellingsen & Monteiro, 2003; Ellingsen & Monteiro, 2006), but a majority of studies has focused on integration of IT solutions for one group of stakeholders, one function or one work practice. In health care, the focus of integrations studies has typically been clinical professionals including doctors and nurses (Fitzpatrick & Ellingsen, 2013), with a focus on only one stage of the patient care process (Drupsteen et al., 2013). Previous research has shown that patient flow optimization within only one department or function can exacerbate problems in other departments (Haraden & Resar, 2004).

To support interdepartmental "business processes within organizations effectively, the existing information systems must be integrated" (Hasselbring, 2000, p. 34). Integration entails organizational entities not acting as functional silos, but as a unified whole (Barki & Pinsonneault, 2005). This is a non-trivial task in organizations, where autonomous departments have acquired and maintained (legacy) information systems over a long time, which is the case in most general hospitals. Our investigation is concerned with workflow-oriented use of IT and how it contributes to integration by breaking down functional silos and barriers through information sharing (Zhao, Huo, Selen, & Yeung, 2011). By *workflow IT*, we refer to IT tools and solutions that support organizational processes and enable sharing and integration of information, which typically reside in isolated information systems, across specialists' (medical treatment) work processes and functions (Lenz & Reichert, 2007). Workflow IT thus primarily strengthen workflow coordination through integration across many different systems, which have usually been optimized for the support of different medical disciplines (e.g. radiology, cardiology, or pathology), but not for cross-departmental workflows (ibid). Practically, this can be achieved by implementing "integration profiles" and a shared workflow-oriented frontend solution that is easily

accessible across functions, for instance through an enterprise service bus architecture, on "lightweight IT" such as whiteboards and smartphones (Bygstad, 2015).

Recently, hospitals have begun to experience success in the employ of workflow oriented IT innovations to improve patient logistics (van Lent, Sanders, & van Harten, 2012), through clinical pathways (Rotter et al., 2010), and supply chain management (De Vries & Huijsman, 2011), which is a systematic view of the flow of hospital resources. Bygstad (2016, p. 2) characterize this emergent trend as being "driven by competent users' need for solutions, enabled by the consumerization of digital technology, and realized through innovation processes". The potential for integrative use of IT in hospitals has increased with the adoption of commercially available electronic whiteboards, smartphones and tables (ibid). Key areas for workflow-oriented use of IT (France et al., 2005), is to improve patient flow and facilitate efficient use of hospital resource such as medical equipment, machinery and hospital beds.

2.1 Improving bed turnaround time

A key productivity challenge in modern emergency unit hospitals is bed availability (Fatovich, Hughes, & McCarthy, 2009), which can be addressed, at least in part, by optimizing patient flow. Productivity of housekeeping work in hospitals relates to patient flow through the notion of *bed turnaround time* (Craven et al., 2006; McClelland et al., 2011; Wilson & Nguyen, 2004), which constitutes the time from a hospital bed becomes vacant until the bed has been cleaned or replaced to make room for a new patient. Hence, bed turnaround time does not only constitute the cleaning routine itself, but also the coordination between those who require the housekeeping service, often a nurse, and those who perform it. Wilson and Nguyen (2004) report on how the housekeeping staff at a University Hospital in San Antonio arrived at a low-cost, low-tech solution that reduced bed turnaround time from 160 minutes to 30 minutes. The solution consisted of the placement of two jars at the nurses' station. Once a patient was transferred or discharged, the nurse put a red note with the patient's room number into one of the jars. When housekeeping staff finished cleaning the room, they removed the red note from the first jar and put a green note with the same room number on it in the second jar. The green note served as a reminder that a room was available. Overall, the simple and low cost measure reduced the patient throughput time at the emergency department with as much as 8.5% (McClelland et al., 2011, p. 1394), which indicates the direct impact bed turnaround time can have on patient flow.

Similarly, Craven et al. (2006) report on an initiative where a combination of coordination challenges between nurses and housekeepers and a lack of available housekeepers during lunch time and shift handovers led to inflated bed turnaround time. By providing housekeepers with pagers and adjusting work schedules the bed turnaround time came down "from 101 minutes to about 50 minutes. This improvement has been sustained at this level for more than a year and has been valued at more than $700,000 annually, in addition to increasing bed capacity and improved patient satisfaction" (ibid, p. 16). In the study reported on here, we focus on the impact of workflow-oriented use of IT on bed turnaround time, as it allows us to highlight the importance of involving hospital support services, such as housekeeping, in hospital process innovation with workflow IT.

3 THE THEORY OF SWIFT, EVEN FLOW

The Theory of Swift, Even Flow originates from the field of operations management to account for why one operation (factory or service) is more productive than another (Schmenner & Swink, 1998). It has subsequently been adapted to study productivity in service organizations in general (Schmenner, 2004) and hospitals in particular, such as intra-departmental logistics (Fredendall et al., 2009) and the general impact of IT on hospital patient flow (Devaraj et al., 2013).

The Theory of Swift, Even Flow holds that the more swift and even the flow of materials (or information) through a process, the more productive is that process (Schmenner, 2004; Schmenner & Swink, 1998). "Thus, productivity for any process—be it labor productivity, machine productivity, materials productivity, or total factor productivity—rises with the speed by which materials (or information) flow through the process, and it falls with increases in the variability associated with the flow, be that variability associated with quality, quantity or timing" (Schmenner, 2004, p. 335). Schmenner & Swink (1998) derive the Theory of Swift and Even Flow from five basic laws in operations management that

have a bearing on productivity; the law of variability, the law of bottlenecks, the law of scientific method, the law of quality and the law of factory focus.

Schmenner and Swink (1998) outline the five laws that constitute the Theory of Swift, Even Flow as follows – (i) The law of variability, based upon queuing theory, proposes that the greater the variability the less productive the process is. Variability is reduced when the demands placed on the process are even and regular. (ii) The law of bottlenecks suggests that a process is only as fast as its slowest stage. A productivity bottleneck can either be eliminated, mitigated by adding capacity, or accommodated by maintaining consistent production through it. (iii) The law of scientific methods, from Industrial Engineering, holds that scientific methods are means by which nonvalue-added motions and steps can be mitigated and by which value-added steps can be done faster, without additional strain. (iv) The law of quality relates improvements in productivity to improvements in quality, such as through improved product design, changes in materials or processing, primarily because of the implied production stability and reduction of waste. Temporary bottlenecks to productivity are often caused by quality problems that force rework, instrument downtime and flow interruptions. (v) The law of factory focus holds that factories and service providers that focus on a limited set of tasks will be more productive than similar factories with a broader array of tasks. By grouping like products and processes together, the flows of materials (or information) become more transparent and permits the identification of bottlenecks.

Following the five laws of the theory, *process throughput time* is a critical performance measure in facilitating swift and even flow (Schmenner, 2004; Schmenner & Swink, 1998). Throughput time measure the "speed of the flow from the point where materials for a unit of the product are first worked on until that unit is completed [and] is particularly useful as a mechanism to isolate where flows have become retarded or blocked" (Schmenner & Swink, 1998, p. 102) . Devaraj et al. (2013) further note that in the context of hospitals, process throughput time corresponds to consistent, timely, and error-free patient flow and that the Theory of Swift, Even Flow predicts that "hospitals that have mastered the rapid and steady movement of patients would perform better than hospitals that have not" (ibid, p. 183).

Workflow-oriented use of IT can play a pivotal role in improving patient flow by strengthening information transparency and facilitating coordination to overcome emergent bottlenecks, for instance caused by overcrowding at the hospital emergency department (McClelland et al., 2011; McHugh, VanDyke, McClelland, & Moss, 2012). In this study, we employ the Theory of Swift, Even Flow to investigate the role of workflow IT in facilitating improved patient flow. If workflow IT contributes to patient flow performance it is likely to do so by overcoming one or more of the barriers to flow identified by Schmenner & Swink (1998). That is, workflow IT either reduces the variability associated with patient flow or helps in mitigating bottlenecks or non-value-added activities.

4 METHODS

We chose Kalnes hospital for our empirical case study, because we were aware that the management of the brand new hospital had explicit ambitions to improve patient flow through IT mediated coordination and information visibility across hospital departments. Furthermore, Kalnes hospital has one of Norway's largest emergency units in addition to general hospital functions such as delivery wards and clinical and surgical departments. Hence, we considered Kalnes hospital an extreme case both in terms of variability in patient flow and in terms of the level of technical integration associated with the IT solutions employed to support workflow coordination (Gerring, 2007).

With the construction of Kalnes hospital, a custom workflow oriented software called IMATIS was configured on digital whiteboards, workstations and Windows Phone clients. The electronic whiteboards provide up to date information for patients, their families, clinical professionals assigned to patients and hospital support staff. IMATIS also serves as a middleware to integrate the hospitals main information systems including electronic patient records, Radiological Information Systems (RIS), Picture Archiving and Communication Systems (PACS), lab, and the personnel administration system. In all hospital departments, the electronic whiteboards visualize information about patient flow such as patient tests and outcomes in addition to information about available hospital resources. The integration of extant data repositories into one workflow-oriented frontend software allows for the cross-departmental reservation and booking of hospital resources and services. For example, when a nurse require

housekeeping, she books the service either by using a digital whiteboard or a workstation with IMATIS software. Kalnes hospital is an exemplary case for the study of how IT can contribute to patient flow by facilitating cross-departmental coordination. With a predominantly open-ended and qualitative case study research design our ambition was to arrive at explanations about how workflow oriented use of IT can improve hospital responsiveness to variability and mitigate patient flow bottlenecks.

4.1 Data collection and data analysis

Through initial meetings with process designers in charge of efforts to improve patient flow at Kalnes, we learned that the housekeeping department had been particularly successful in revising their internal work processes and work schedules to accommodate cross-functional workflow interdependencies. The first author followed up on this lead by conducting interviews with the management team at Kalnes hospital housekeeping department. This provided an overview of the restructuring and work process adjustments that had taken place immediately after the transfer from the old hospital in Fredrikstad and after about one year of operation at Kalnes. Subsequently the author spent three days shadowing six housekeepers, three of which had transferred from Fredrikstad hospital. Taken as a whole, our data collection led us on a journey from a focus on process design at Kalnes to alleviate patient flow bottlenecks, to active management of workflows at the housekeeping department, to housekeepers performing their tasks at different wards, including the emergency department where the *variability* of work is notably higher. At this point our empirical investigations had become sensitive to how variability at the emergency department would impinge on other hospital departments and support functions and impact patient flows.

We went on to investigate the use of data concerning housekeeping performance that was being captured through IT at Kalnes. We did this first through interviews with data analysts and then through participation in a number of patient flow oriented meetings with both an operational focus and with a strategic agenda of arriving at informed interventions to improve patient flows. Importantly, through our longitudinal engagement with process designers at Kalnes, we obtained ten internal observation notes generated between autumn 2016 and spring 2017. These had been developed specifically to identifying patient flow bottlenecks. The observation notes helped us populate a timeline with key changes to doctors', nurses' and emergency unit coordinators' coordinative practices, based on observed inefficiencies, misconceptions and bottlenecks at different points in time and at different departments including the emergency department and housekeeping. The observation notes documented how coordinative practices emerged at the new hospital and when major changes to housekeeping routines and workflow coordination had been introduced.

We introduced The Theory of Swift, Even Flow as a theoretical lens at a late stage of the study, because it coincided with our empirical observations of patient flow variability and bottlenecks and allowed us to analyse how and why workflow IT had a positive impact on housekeeping productivity. The law of variability, the law of bottlenecks, the law of scientific method, the law of quality and the law of factory focus provided distinct categories for our sorting of interview and observation data and allowed us to investigate how variability, temporary bottlenecks and non-value added activates were mitigate through the use of workflow IT at Kalnes. We have primarily based our analysis on qualitative interviews and observations. However, quantitative data obtained from the analytics department at Kalnes has helped us verify some of the trends indicated by our informants about the impact of different revisions and adjustments on productivity indicators such as bed turnaround time in particular and patient flow in general. In conjunction, our sensitization to the Theory of Swift, Even Flow and our development of a timeline regarding major shifts in the interdepartmental use of workflow IT at Kalnes allowed us to derive three distinct stages of IT mediated workflow integration maturity, which we outline in the discussion section of the paper.

5 IT MEDIATED HOUSEKEEPING AT KALNES HOSPITAL

Kalnes general hospital officially opened in November 2015 and replaced three older hospitals in the region, with the hospital in Fredrikstad being the largest of the three. Kalnes shares the responsibility for a population of about 270.000 together with the smaller Moss hospital, which does not operate an emergency unit. Kalnes hospital has only four floors dedicated to health service provision, with a

basement for support functions and a top floor for technical infrastructure. Most staff, including housekeepers, that worked at Fredrikstad hospital transferred to Kalnes with the opening of the new 85.500 square meter hospital. Housekeeping work changed substantially both in terms of housekeeping routines and its coordination.

5.1 Housekeeping as an on demand service

At Kalnes hospital, patients stay in single bedrooms, each with a small bathroom. Housekeepers clean the room upon every patient transfer or discharge. The cleaning routine takes between 18 and 25 minutes depending on the type of room and the potential type of contagion. This was not the case at Fredrikstad, where rooms with two or four patient beds were cleaned once a day, irrespective of patient transfers or discharges. Whenever patients were discharged at Fredrikstad, the nurse in charge of the patient would take the bed to a bed carousel and put a new bed in place for the next patient. In addition to on demand housekeeping, housekeepers at Kalnes clean examination rooms, treatment rooms and occupied patient rooms where there has been no transfers or discharges on a daily routine basis.

All hospital staff, including doctors, nurses and housekeepers, log on to the IMATIS platform at the start of their shifts, but the information, resources and actions they have access to vary with their roles, team memberships and physical location within the hospital. At the beginning of a shift, a housekeeper sings into both IMATIS and the housekeeping logistics software called CleanPilot. The housekeeper will then have access to a visual overview of the hospital layout and the daily routine work to be performed (CleanPilot), and pending housekeeping tasks (IMATIS). Housekeepers verify the location of incoming orders in CleanPilot on an Apple Ipad mounted on their trolleys. In addition, housekeepers use the IMATIS "worklist" on Windows Phone clients for changing task status from "housekeeping ordered" to "housekeeping in progress". The housekeeper then performs the necessary cleaning routine and register the task completion in both CleanPilot and IMATIS. This allows housekeepers within the same team to keep track of which rooms in their zone have been cleaned due to a patient discharge or transfer and hence do not require daily routine cleaning. Housekeepers also use CleanPilot to record the cause of wasted trips such as the patient was still in the room.

Housekeepers that transferred from Fredrikstad remarked that housekeeping work has become physically harder, less predictable, lonelier and more stressful at Kalnes. Some of the physical strain relates to the fact that there was less to clean in each room at Fredrikstad. For instance, removing used bedlinen was the task of nurses, but is now the responsibility of housekeepers. Furthermore, Fredrikstad hospital was a tall and slender building with different clinical departments on each floor. This is contrasted by the four healthcare delivery floors at Kalnes with long hallways where housekeepers push big trolleys and pull heavy bags of dirty bedlinen all day. Lastly, housekeeping work was predictable and consisted almost exclusively of prescheduled daily routine tasks. Consequently, there was no need for extensive registration and coordination of housekeeping activities.

Housekeepers at Kalnes work in teams within designated zones. During the first year of operation, one team in one zone could be running from room to room, especially the team assigned to the emergency department, while other housekeeping teams had no assignments at all. Specifically, during our early observation visits, we talked to idle housekeepers that praised themselves lucky for not being part of the busy emergency department shift. A nurse at the emergency unit commented on the coordination with the housekeeping service. "I know the cleaning routines itself takes less than 30 minutes, but sometimes it takes three hours from a room is registered in IMATIS until the cleaning is performed". Anecdotally, the emergency unit documented the following episode during an internal observation study. Two rooms, that were adjacent to each other, had patient transfers confirmed both within half an hour. After one hour, a housekeeper came to clean one of the rooms, but the other room was cleaned half an hour later, by a different housekeeper.

In addition, there were a number of early challenges with using IMATIS for workflow coordination. For example, during one of our rounds of observation a nurse came up to a housekeeper to point out that she had booked a housekeeping task in IMATIS a while ago. The housekeeper then checked her IMATIS worklist, but she was not able to find the mentioned task. The housekeeper then instructed the nurse to "please go back [to the computer] and register the task again, or I will not be able to do it." In general, nurses, housekeepers and other hospital staff experienced initial challengers with adjusting to the idea

of housekeeping as an on demand service. Over time, however, a number of initiatives emerged to improve the use of IMATIS as a workflow coordination tool throughout the hospital.

5.2 Information sharing for tightened workflow integration

Every morning at around 08:50 each clinical department at Kalnes gather for a ten minutes whiteboard meeting, where participants briefly discuss the statuses of the patients admitted to the department. A key output from the meeting is the update of patient statuses in IMATIS through live interactions with an electronic whiteboard. Patients likely to be discharged are given the status "possible discharge", while patients confirmed for discharge are given the status "confirmed discharge". This information is immediately shared across hospital departments. For the housekeeping departments this provides a projection of upcoming tasks. Subsequently, during the doctors' round of morning patient visits, ideally conducted before 10:30, the doctor further clarifies the discharge status of patients. The doctor or a nurse should then update this status through IMATIS as soon as possible, so that housekeepers and porters can provide required services, but doctors have been reluctant to register patient discharges in IMATIS directly. Doctors highlight that IMATIS generates administrative overhead and provides limited benefits to their primary clinical duties. They still have to enter the same information, together with more detailed information about the patient, in electronic patient records. Typically, doctors only access their workstations after the morning round of patient visits.

Lackluster interest among doctors to update patient status information directly in IMATIS or to instruct the nurse in charge of the patient to do so hampered the housekeeping department's ability to anticipate patient discharges. Furthermore, patient discharges should ideally be confirmed before noon, but in practice, as a nurse reflects, "patients are discharged throughout the whole day, in order to make way for new patients".

Somewhere between 90 and 120 patients, arrive at Kalnes emergency unit every day. The number of arriving patients increases throughout the day with "peak hours" around 1:30 P.M. The emergency unit experiences coordination challenges associated with the transfer of patients to other hospital departments for appropriate treatment and follow-up, especially during "peak hours". Each department has a coordinative nurse tasked with facilitating patient flow. The coordinative nurse at the emergency department has extended administrative rights in IMATIS to oversee patient transfers in all other hospital departments, alter reservations and prioritize already registered tasks, such as a particular housekeeping task at a particular ward, to hasten their completion and alleviate the patient burden at the emergency unit. This flexibility on behalf of the emergency unit allows some measure to be taken in order to mitigate emergency unit overcrowding during peak hours.

As a rule, a priority housekeeping task should be initiated within 20 minutes. However, nurses who are too busy to interact with a whiteboard or a workstation between every patient encounter, sometimes register multiple rooms in need of housekeeping simultaneously. These are then pushed in bulk to the housekeeping team assigned to the zone where the nurse places the order. Similarly, some coordinative nurses tend to upgrade the priority status of pending housekeeping tasks in bulk. This effectively negates the effect of the priority setting, because there are only a fixed number of housekeepers assigned to each zone and the average time required to complete a housekeeping task is between 18 and 25 minutes. Due to complaints from the housekeeping department, the practice of over-utilizing the priority setting has been mitigated by limiting the rights to upgrade housekeeping tasks to priority setting to the coordinative nurse at the emergency unit. This and other adjustments to the IT mediated coordination of housekeeping tasks have been implemented as part of a continuous patient flow oriented performance monitoring and process innovation initiative at Kalnes.

However, limited trust in the quality of IMATIS registrations among hospital staff and challenges with identifying temporary patient flow bottlenecks a process designer at Kalnes reflected: "one year of process innovation – unfortunately gave little impact on patient flow. We had to approach the problems more systematically by instituting patient flow seminars and engage departments in data analysis and discussion". Hospital management realized that transparent information across departments was not enough and the focus on workflow IT at Kalnes shifted from ad hoc workflow coordination between departments to hospital-wide initiative to identify patient flow bottlenecks.

5.3 Beyond integration: striving for synchronization through collaboration

During autumn 2016 Kalnes hospital management, by the process director, mandated the establishment of a weekly 25 minutes transdisciplinary Friday patient flow conference. The conference centers on the presentation and discussion of workflow-oriented statistics, produced by the analytics department, such as the length of patients' stay at the emergency unit and waiting time associated with housekeeping tasks. The purpose of the meeting is to evaluate performance, develop plans, and discuss how to implement workflow coordination improvements. For example, one concrete recommendation that was propose and subsequently implemented, was to rebalance the distribution of bed capacity between departments. The heart department increased its capacity by obtaining hospital beds from other departments that were less burdened. This intervention was motivated by statistical analyses of the numbers of patients hospitalized outside their respective departments, such as the number of heart patient hospitalized and treated while residing at the lung department.

The weekly patient flow conference brings together dedicated workflow coordinators, department heads, clinicians and representatives of support staff across departments to strengthen the collective insight into different functions' work processes and their interdependencies. Initially, the housekeeping department was not invited to partake in the patient flow conference. As the housekeeping department manager indicates with a smile "it is a bit easy to forget about the support functions, but we managed to nag our way in [during the last quarter of 2016]". Recurring complaints about long waiting time for housekeeping services have surfaced during the patient flow conferences. Based on performance statistics from IMATIS and feedback during the patient flow conferences, the management of the housekeeping department reorganized team compositions and housekeeping staff shifts once during 2016 and during January 2017.

Initially, housekeeping teams would either respond to housekeeping bookings in IMATIS or perform the daily routine housekeeping. However, to mitigate bottlenecks, especially during "peak hours", this division of labor was revised so that all 18 housekeeping teams at work should prioritize bookings in IMATIS and only return to daily routine tasks when the IMATIS worklist is empty. In addition, during January 2017, the working hours of the housekeepers were altered to better align with actual housekeeping demands. Whereas the majority of housekeepers initially worked day shifts from 07:00 to 15:00, with evening shifts signing in at 13:30, the new core working hours for the day shifts were adjusted to 09:00 to 17:00, while additional housekeeping capacity were assigned to Friday evenings to reflect the recurring spike in patient discharges before the weekend. Figure 1 illustrates the effect the housekeeping departments informed revisions has had on "bed turnaround time" i.e., the time from a housekeeping task is booked until it is completed. The graph shows the trend from January 2017, when the latest revisions were initiated, until December 2017. The average goes up in July / August and December, but this is most likely due to the use of non-permanent housekeeping staff during vacations.

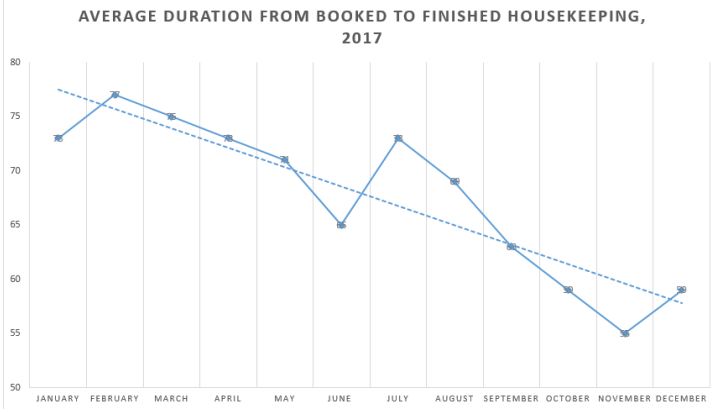

Figure 1 Illustrates improvement in "bed turnaround time" during 2017

The housekeeping department has received praise from data analysts, process designers and the hospital management at Kalnes for their efforts to adjust and restructure their work, including working hours,

team compositions and internal divisions of labour, based on analytics generated from data registered through the IMATIS software. Interestingly, the housekeeping department has also been able to draw on data from IMATIS and CleanPilot to illustrate how its performance has been affected by factors beyond their immediate control. Specifically, the housekeepers register all exceptions and extra work in CleanPilot. By correlating CleanPilot data with reports generated from IMATIS, the housekeeping department has been able to highlight the problem of erroneous bookings and misuse of priority status on housekeeping tasks. By documenting the frequency of these different errors the housekeeping department has recommended adjustments to the practices of specific hospital functions, such as the coordinative nurses. For instance, a common problem has been that some nurses register the housekeeping task before the patient has left the room or before medical equipment has been removed from the patient room. Consequently, the housekeeping department has engaged in dialogue with departments where premature bookings have been most prevalent. Over time, the use of IMATIS for integrated workflow coordination has generated a rich repository of data that provides a backdrop for organizational learning and process innovation to improve patient flows.

6 ANALYSIS

According to the Theory of Swift, Even Flow, the swifter and more even the flow of materials (or information) through a process, the more productive is that process (Schmenner, 2004; Schmenner & Swink, 1998). In a hospital setting this principle, which highlights throughput time as a measure of productivity, translates to consistent, timely, and error-free patient flow (Devaraj et al., 2013). A number of patient oriented workflows including admittance, triage, treatment and transfers affects patient flow. Specifically, "bed turnaround time" is a key productivity measure that is closely linked to the performance of the housekeeping department. At Kalnes, bed turnaround time was experienced as a patient flow bottleneck. To account for how workflow IT was able to produce a positive impact on bed turnaround time, we consider our empirical findings in relation to each of the five laws of the Theory of Swift, Even Flow; the law of variability, the law of bottlenecks, the law of scientific method, the law of quality and the law of factory focus.

The law of variability proposes that the greater the variability the less productive the process is. Variability is reduced when the demands placed on the process are even and regular. High variability is inherent to an emergency unit and cannot be alleviated significantly from the process input side. However, doctors could ensure a more even cross-departmental workflow by registering patient transfers and discharges in a timely manner. Overall, workflow IT has allowed departments at Kalnes to share patient flow information, which allows department responsible for subsequent steps to anticipate the workload and schedule resources and services, including support services such as ambulances and housekeeping. The variability in patient transfers and discharges throughout the day created a highly uneven demand on those housekeeping teams that were originally assigned to only deal with on demand housekeeping tasks. This variable workload led to temporary bottlenecks, particularly during peak hours. To counteract a high degree of variability associated with patient transfers and discharges, the housekeeping department reorganized its teams and instructed all teams to prioritize on demand housekeeping over daily routine tasks. With a higher total capacity to tackle variability, temporary bottlenecks were mitigated faster.

This capacity revision was in line with the *law of bottlenecks*, which suggests that a productivity bottleneck can be mitigated by adding capacity or maintaining consistent production through it. The daily routine tasks could be performed in periods of the day when the number of incoming orders were lower. Furthermore, by highlighting the problem of housekeeping tasks being order and prioritized in bulk, the housekeeping department was able to instruct coordinative nurses throughout the hospital to moderate this behavior and ensure a more even and consistent flow of bookings. Furthermore, the rights to prioritize housekeeping task was restricted to the emergency department and the practice of upgrading priority settings on booked tasks in bulk was discouraged.

To mitigate the daily peak hour bottleneck the housekeeping department made substantial revisions to work schedules and adjusted core working hours from 07-15 to 09-17 during January 2017. Additional capacity was also added to Friday evening shifts as data analysis revealed that patient discharges peak before weekends, with patients wishing to spend the weened at home with their families. Analysis of

historical data retrieved from the workflow-oriented use of IT allowed the housekeeping department to identify these trends in temporary bottlenecks. The data analysis and discussions conducted as part of the transdisciplinary patient flow conferences as well as the internal patient flow observation studies played an instrumental role in the identification of patient flow bottleneck associated with housekeeping work. Through a combination of altered working hours and merging of booked housekeeping tasks and daily routine work the housekeeping department has increased its overall capacity to respond flexibly and swiftly to emergent temporary bottlenecks. Indicating the success of the housekeeping department in improving its responsiveness, a member of the team who conducted the initial observation studies comment that, "today housekeeping is rarely mentioned during the patient flow seminar, but in the past it was brought up all the time".

The law of scientific methods points to the potential efficacy gains of removing nonvalue-added motions and steps and doing value-added steps faster, without additional physical strain. Overall, information sharing and thigh coordination of resources across departments reduces non-value-added activities by allowing early booking of the required resources and capacities along a patient trajectory, including support services. Since the opening of Kalnes hospital, and the introduction of single patient rooms, the housekeeping department has engaged in activities to time and standardize actual cleaning routines so that efficacy can be facilitated across housekeepers. The housekeeping department uses its own software, called CleanPilot, to coordinate housekeeping activities within a specific team zone and to register the actual duration of each housekeeping task. However, during observation we noticed that many housekeepers simply enter the normalized time for the task at the beginning, rather than the actual time spent at the completion of the task. This limits the value of the data for post hoc analysis and application of scientific methods to identify particularly problematic and time-consuming cleaning routines. Similarly, in terms of IT operations, our observations revealed that many of the digital navigation steps, data registrations and status updates were duplicated on IMATIS and CleanPilot. Housekeepers could thus avoid extensive non-value added interaction with the IT tools if IMATIS and CleanPilot had been integrated. Avoiding double registration also tends to have a positive effect on data quality, but an integration between the two software products has not been considered a budgetary priority by the hospital management.

The law of quality relates improvements in productivity to improvements in quality, such as through improved product design, changes in materials or processing, primarily due to the implied stability and reduction of waste. At Kalnes, erroneous bookings initially led to wasted trips whereby housekeepers would show up to patient rooms only to find the patient in the bed or medical equipment left in the room. This would either result in the housekeeper having to try to identify and retrieve the responsible nurse to clarify the situation, or to register the booking as a wasted trip in IMATIS. With a combination of data from IMATIS and CleanPilot, the housekeeping department has been able to demonstrate erroneous bookings affects housekeeping performance. This information has been used to engage in dialogue with the clinical departments responsible for the majority of erroneous bookings, which, according to the housekeeping management, has led to subsequent improvements. As one housekeeper commented, "it used to happen all the time, but now it has been weeks since I had a wasted trip".

The law of factory focus holds that operations that focus on a limited set of tasks will be more productive than similar operations with a broader array of tasks. By grouping like products and processes together, the flows of materials (or information) are made more transparent, which permits the identification of bottlenecks and of non-value-added steps. There are many reasons to avoid the comparison of a general hospital to a factory, not the least due to the inherent heterogeneity and deep specialization of the services provided. However, the use of workflow IT, in this case the IMATIS software, has increased information transparency and ignited an interest throughout Kalnes hospital to focus on productivity, through the continuous capture and analysis of patient flow information. Where can variance be evened out and by whom? Where do temporary bottlenecks emerge and how can departments coordinate better to mitigate the bottlenecks? The broad cross-departmental participation in the weekly patient flow conferences and the holistic investigate of patient flow bottlenecks has allowed management hospital "productivity" thinking to seep into different departments work processes and has resulted in departments adopting workflow-oriented commitments.

7 DISCUSSION AND CONCLUSION

We introduced this empirical study with the research question: how can workflow IT improve hospital housekeeping responsiveness to patient flow variability and mitigate temporary patient flow bottlenecks? We chose Kalnes hospital to study the novel use of workflow IT across hospital departments and we applied the Theory of Swift, Even Flow (Schmenner & Swink, 1998) to analyse our findings and explain how and why workflow IT was able to have a positive impact on housekeeping productivity. Overall, we find that workflow IT leads to tighter integration between support services and primary clinical processes. While the increased visibility of support services across departments and function may trigger external pressure to introduce work practice changes, it may also make support services more appreciated in terms of contributions to a shared professional goal of improved patient flow.

At Kalnes hospital, workflow IT has had a positive effect on bed turnaround time, which is an important component of patient flow. This has been achieved by utilizing workflow IT both for real time coordination of housekeeping tasks but also as a source of workflow data for post hoc data analysis and identification of variability, temporary bottlenecks and non-value added work. The housekeeping department at Kalnes has leveraged information captured through IMATIS and CleanPilot to revise the division of housekeeping work, work schedules, working hours, and cleaning routines, to improve their responsiveness to cross-departmental workflows. Our study has important implications for hospital management and investments in workflow IT, especially given that emergency unit overcrowding has become an increasing hospital administration problem. Improving patient flow is an important political agenda, which is directly tied to healthcare expenditure patient safety and patient satisfaction. In the following, we outline three levels of IT mediated workflow integration maturity in hospital information systems ranging from workflow *transparency* to *synchronization* and *responsiveness*.

General hospitals typically have a functional structure, with most information residing in isolated silo systems (Lenz & Reichert, 2007; Zhao et al., 2011). A first step towards integrated workflows is the establishment of information transparency across interdependent departments, including support services, which cater for different steps in the patient care process (Drupsteen et al., 2013). During the initial transparency stage of workflow integration, hospital departments update and share information about their available resources, patient trajectories, and potential transfers and discharges relevant to the planning and control of patients across departments. Novel IT solutions that leverage electronic whiteboards and smartphones affords expedient and accurate workflow information that was previously opaque between departments. Information transparency can help reduce variability by allowing for preemptive planning across departments and it can reduce non-value added steps and patient waiting time in between patient-oriented process steps.

At Kalnes hospital, the initial information transparency stage gradually transitioned into what we have chosen to refer to as the synchronization stage of IT mediated workflow integration. This stage was enabled by increasing trust in the workflow information, which emerged through a combination of managerial direction and interdepartmental consensus building and negation. Increasing trust in workflow information raised the willingness to alter internal processes to accommodate interdepartmental needs. At this stage, the hospital management and the different department leaders became engaged in efforts to even the patient flow, mitigate bottlenecks and limit the overuse and underuse of resources across departments. At the housekeeping department, this resulted in a need to become more dynamic, with changes in working hours and general adaptation to trends in patient flow. Limited or erroneous use of workflow IT to book resource and service across departments were rectified to improve the overall productivity of the hospital and alleviate bottlenecks. However, as the hospital management at Kalnes recognized, there was no clearly identifiable improvements to hospital patient flow, despite the widespread use of workflow IT to book and coordinate resources and activities.

This recognition guided the transition from using workflow IT primarily as a coordinative tool (i.e. synchronization), to using it also as a source for analytics and cross-departmental investigations and open forums for interpretations and discussions. This lead to the inclusion of all departments, including the support functions that had been initially left out of the planning, design and implementation of the workflow IT solutions, in weekly patient flow seminars. We refer to this third stage of workflow

integration as the responsiveness stage, where different departments become more sensitive to the internal dynamics of other departments and what can be done to respond better to cross-departmental variability in patient flow and the emergence of temporary patient flow bottlenecks. At this stage, the capacity and resources of different departments are integrated more tightly through joint patient trajectory planning, guided by a centrally mandated objective of improving patient flow. This of course puts additional obligations on hospital departments that have traditionally been accustomed to work in functional silos and requires the establishment of forums for participative negation and coordination so that emergent tensions do not go unresolved. At general hospitals, where professionals time is scarce, such forums for process improvement requires strict time management and structure as was the case with the establishment of the daily morning whiteboard meeting in each department and the Friday patient flow seminar across all departments.

8 CONCLUDING REMARKS

In this empirical study, we have seen that workflow-oriented use of IT can improve hospital productivity. We have looked at how workflow IT improved the productivity of the housekeeping department at a recently opened hospital in Norway. This may be particularly important if "bed turnaround time" is a recurring temporary patient flow bottleneck that affects the overall productivity of the hospital. Beyond serving as a coordinative tool, workflow IT use can also generate statistics over time that reveal inefficiencies in dealing with variability and temporary bottlenecks. Our study complements extant research on information system integration and workflow oriented use of IT in hospital settings. It highlights the role of the often-overlooked support services vis-à-vis the meticulously studied clinical practice in relation to hospital patient flow. Our findings indicate that an important focus area for hospital digitalization may be to mobilize support functions in workflow oriented process streamlining. Our study also echoes previous research findings concerned with the computerization of clinical practice in that doctors clinical priorities may be notoriously difficult to align with hospital managers visions of productivity and performance optimization. Our study indicates that it may be beneficial to rely on alternative roles such as dedicated coordinators and nurses assigned to patients to ensure the timely and accurate sharing of workflow information between clinical hospital departments and support services. We believe there is need for more research that explore the potentials for productivity gains through workflow-oriented use of IT in hospitals. In particular, we would like to encourage studies that consider workflow coordination between multiple hospital departments, including support services.

The workflow-oriented use of IT throughout Kalnes hospital has played an instrumental role in informing the housekeeping department and their compatriots' efforts to ensure swifter and more even patient flow. Workflow data from IMATIS, in addition to specific data from CleanPilot allowed the housekeeping department to arrive at revisions, which resulted in a reduction in the average "bed turnaround time" from around 70 minutes in January to about 55 minutes in November. Similarly to the hospital housekeeping productivity gains documented by Craven et al. (2006), the potential of digitalization of housekeeping workflows is realized through a combination of swift real-time coordination and informed revisions to work schedules and divisions of labor to mitigate recurring temporal bottlenecks. To hospital managers, we caution against a narrow focus on improved housekeeping performance with IT. Previous research shows that patient flow optimization within only one department or function can exacerbate problems in other departments (Haraden & Resar, 2004). The experience from Kalnes highlights that process innovation in relation to patient flow is a hospital-wide endeavor and rely on the workflow-oriented participation and judgment of doctors, hospital administrators, porters and housekeepers alike.

9 REFERENCES

Aronsky, D., Jones, I., Lanaghan, K., & Slovis, C. M. (2008). Supporting patient care in the emergency department with a computerized whiteboard system. *Journal of the American Medical Informatics Association*, *15*(2), 184–194.

Bamford, D., & Griffin, M. (2008). A case study into operational team-working within a UK hospital. *International Journal of Operations & Production Management*, *28*(3), 215–237.

Barki, H., & Pinsonneault, A. (2005). A model of organizational integration, implementation effort, and performance. *Organization Science*, *16*(2), 165–179.

Bygstad, B. (2015). The Coming of Lightweight IT. In *Proceedings of the ECIS conference, Munster, May*. Retrieved from http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1021&context=ecis2015_cr

Bygstad, B. (2016). Generative innovation: a comparison of lightweight and heavyweight IT. *Journal of Information Technology*. Retrieved from http://link.springer.com/article/10.1057/jit.2016.15

Craven, E. D., Clark, J., Cramer, M., Corwin, M. D., Steven, J., Cooper, M. D., & Reich, M. (2006). NewYork-Presbyterian Hospital uses Six Sigma to build a culture of quality and innovation. *Global Business and Organizational Excellence*, *25*(4), 11–19.

De Vries, J., & Huijsman, R. (2011). Supply chain management in health services: an overview. *Supply Chain Management: An International Journal*, *16*(3), 159–165.

Devaraj, S., Ow, T. T., & Kohli, R. (2013). Examining the impact of information technology and patient flow on healthcare performance: A Theory of Swift and Even Flow (TSEF) perspective. *Journal of Operations Management*, *31*(4), 181–192. https://doi.org/10.1016/j.jom.2013.03.001

Drupsteen, J., van der Vaart, T., & Pieter van Donk, D. (2013). Integrative practices in hospitals and their impact on patient flow. *International Journal of Operations & Production Management*, *33*(7), 912–933.

Ellingsen, G., & Monteiro, E. (2003). Big is beautiful: electronic patient records in large Norwegian hospitals 1980s-2001. *Methods of Information in Medicine*, *42*(4), 366–370.

Ellingsen, Gunnar, & Monteiro, E. (2006). Seamless integration: standardisation across multiple local settings. *Computer Supported Cooperative Work (CSCW)*, *15*(5–6), 443–466.

Fatovich, D. M., Hughes, G., & McCarthy, S. M. (2009). Access block: it's all about available beds. *Med J Aust*, *190*(7), 362–3.

Fitzpatrick, G., & Ellingsen, G. (2013). A review of 25 years of CSCW research in healthcare: contributions, challenges and future agendas. *Computer Supported Cooperative Work (CSCW)*, *22*(4–6), 609–665.

France, D. J., Levin, S., Hemphill, R., Chen, K., Rickard, D., Makowski, R., … Aronsky, D. (2005). Emergency physicians' behaviors and workload in the presence of an electronic whiteboard. *International Journal of Medical Informatics*, *74*(10), 827–837.

Fredendall, L. D., Craig, J. B., Fowler, P. J., & Damali, U. (2009). Barriers to swift, even flow in the internal supply chain of perioperative surgical services department: A case study. *Decision Sciences*, *40*(2), 327–349.

Gerring, J. (2007). *Case study research: principles and practices*. Cambridge University Press Cambridge. Retrieved from http://www.lavoisier.fr/livre/notice.asp?id=OA3WRSAA63SOWO

Haraden, C., & Resar, R. (2004). Patient flow in hospitals: understanding and controlling it better. *Frontiers of Health Services Management*, *20*(4), 3.

Hasselbring, W. (2000). Information system integration. *Communications of the ACM*, *43*(6), 32–38.

Hertzum, M., & Simonsen, J. (2013). Work-practice changes associated with an electronic emergency department whiteboard. *Health Informatics Journal*, *19*(1), 46–60.

Hertzum, M., & Simonsen, J. (2015). Visual overview, oral detail: The use of an emergency-department whiteboard. *International Journal of Human-Computer Studies*, *82*, 21–30.

Lenz, R., & Reichert, M. (2007). IT support for healthcare processes–premises, challenges, perspectives. *Data & Knowledge Engineering*, *61*(1), 39–58.

Litvak, E. (2010). *Managing patient flow in hospitals: strategies and solutions*. Joint Commission Resources.

McClelland, M. S., Lazar, D., Sears, V., Wilson, M., Siegel, B., & Pines, J. M. (2011). The past, present, and future of urgent matters: lessons learned from a decade of emergency department flow improvement. *Academic Emergency Medicine*, *18*(12), 1392–1399.

McHugh, M., VanDyke, K., McClelland, M., & Moss, D. (2012). Improving patient flow and reducing emergency department crowding: a guide for hospitals.

Mintzberg, H. (1993). *Structure in fives: Designing effective organizations*. Prentice-Hall, Inc.

Rotter, T., Kinsman, L., James, E. L., Machotta, A., Gothe, H., Willis, J., … Kugler, J. (2010). Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs. *The Cochrane Library*.

Sayah, A., Rogers, L., Devarajan, K., Kingsley-Rocker, L., & Lobon, L. F. (2014). Minimizing ED waiting times and improving patient flow and experience of care. *Emergency Medicine International*, *2014*.

Schmenner, R. W. (2004). Service businesses and productivity. *Decision Sciences*, *35*(3), 333–347.

Schmenner, R. W., & Swink, M. L. (1998). On theory in operations management. *Journal of Operations Management*, *17*(1), 97–113.

Star, S. L., & Strauss, A. (1999). Layers of silence, arenas of voice: The ecology of visible and invisible work. *Computer Supported Cooperative Work (CSCW)*, *8*(1), 9–30.

van Lent, W. A., Sanders, E. M., & van Harten, W. H. (2012). Exploring improvements in patient logistics in Dutch hospitals with a survey. *BMC Health Services Research*, *12*(1), 232.

Villa, S., Barbieri, M., & Lega, F. (2009). Restructuring patient flow logistics around patient care needs: implications and practicalities from three critical cases. *Health Care Management Science*, *12*(2), 155–165.

Wilson, M. J., & Nguyen, K. (2004). Bursting at the seams: improving patient flow to help America's emergency departments.

Wong, H. J., Caesar, M., Bandali, S., Agnew, J., & Abrams, H. (2009). Electronic inpatient whiteboards: improving multidisciplinary communication and coordination of care. *International Journal of Medical Informatics*, *78*(4), 239–247.

Zhao, X., Huo, B., Selen, W., & Yeung, J. H. Y. (2011). The impact of internal integration and relationship commitment on external integration. *Journal of Operations Management*, *29*(1–2), 17–32.