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Non-clinical work counts: facilitating patient outflow in an emergency department

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We conducted an observational study in an emergency department (ED) to acquire an in-depth understanding of the activities and processes involved in the ED patient outflow and the challenges encountered in the outflow coordination with heterogeneous and autonomous stakeholders within and across organisations. We identified that inefficient patient outflow not only led to overcrowding in the ED because patients could not be admitted to the ED, but it also affected the operation of other inpatient units and that of external organisations. Moreover, the overcrowding issue was found to be contingent on how efficiently the multiple, concurrent, and intertwined patient outflow work was coordinated. The patient outflow coordination work was primarily non-clinical, and invisible in the current information system. Therefore, we propose to make the non-clinical coordination outflow work visible and be supported in the information system as efficient outflow is crucial to the efficiency of the overall patient flow.

Keywords: emergency department; overcrowding; patient flow; outflow; non-clinical work

Introduction

Overcrowding in emergency departments (EDs) has been a key barrier to timely emergency care (Asplin et al. 2003; IOM 2006) and a top management problem in hospitals for more than two decades (Gallagher and Lynn 1990; Jones and Olsen 2011; Moskop et al. 2009). EDs are considered overcrowded when the need for emergency services exceeds their available resources, or when the quality of care becomes unsatisfactory as a result of inadequate resources (Gallagher and Lynn 1990; Hwang et al. 2011). Overcrowding often leads to increased wait time, delayed patient care, inappropriate care delivery such as patients being treated in hallways, reduced patient satisfaction, and decreased productivity of healthcare providers.

EDs in the USA including our study site are increasingly overcrowded with long wait times, which have unfortunately been found to jeopardise patient safety (ACEP 2012). This was partly due to the closing down of a large number ($\sim$1000) of EDs, from 5000 in 1991 to 4000 in 2006, leading to a sharp increase in the number of patients seeking emergency care. The Joint Commission mandated hospitals to 'develop and implement plans to identify and mitigate impediments to efficient patient flow' (Joint Commission on Accreditation of Healthcare Organizations 2007). As a result, many efforts have been made to better understand the overcrowding issue in EDs and to investigate how patient flow can be facilitated in order to achieve efficient patient care and optimised use of resources in the ED (Cowan and Trzeciak 2004; Gallagher and Lynn 1990; Hwang et al. 2011; Pines et al. 2011).

Patient stay at the ED is typically composed of three interconnected phases (Figure 1): *patient inflow*, *patient treatment*, and *patient outflow*, corresponding to the input–throughout–output conceptual model (Asplin et al. 2003). ED patient inflow happens when patients demand services of an ED where patients are first assessed and triaged, based on the severity of their illness and the time of their arrival. Patient care in ED often requires prompt evaluation and emergency treatment with the goal to stabilise the patients. Depending on individual patients' medical conditions, ED patient outflow occurs when the patient is ready for *discharge*, *admission* to an inpatient unit, or *transfer* to an external facility. Inefficiencies in any part of these phases would lead to breakdowns such as delays and unnecessary bed occupancy in the ED.

Most early studies attributed the ED overcrowding problem to a shortage of resources. In particular, many studies found that inpatient bed shortage often forced an ED to board inpatients until a bed was available in the inpatient unit. In fact, the inpatient boarding issue that caused unnecessary delay in moving patients from the ED to an inpatient unit has been the most frequently cited reason for ED overcrowding (Derlet, Richards, and Kravitz 2001) and a reason for patient deaths (ACEP 2007). Yet previous attempts to increase resources such as bed availability with the goal to ease overcrowding failed to solve the

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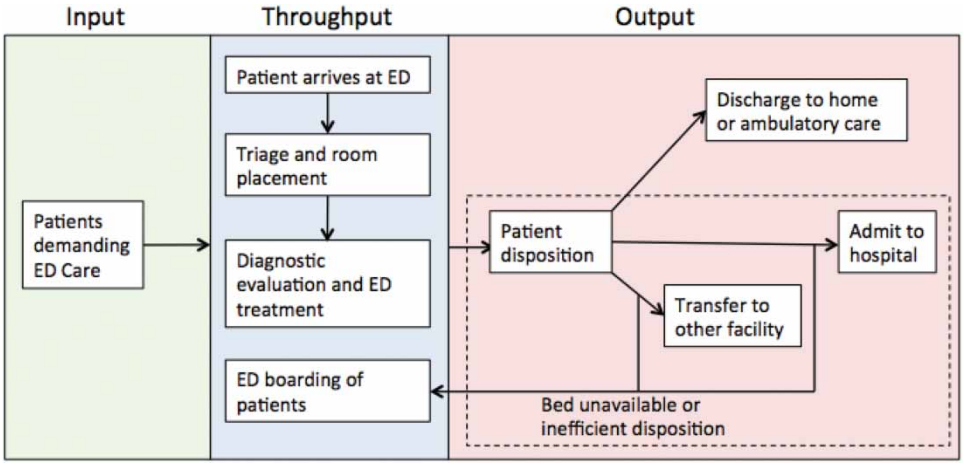

Figure 1. A simplified input–throughout–output model of ED patient flow. Source: Asplin et al. (2003).

problem (Moskop et al. 2009). In fact, more recent studies indicated that the ED overcrowding problem was due to inefficiency or breakdowns in patient flow (Haraden and Resar 2004; Miro et al. 2003; Moskop et al. 2009; Wolstenholme 1999) rather than scarce resources. This is not surprising because inefficient patient flow not only led to overcrowding, but also impacted the utilisation of scarce resources in healthcare settings. For example, inefficient patient flow lengthened patients' stay in an ED, which then required prolonged use of equipment, space, and personnel. Moreover, bottlenecks in the ED outflow would backfire to result in unnecessary delays in the patient inflow to the ED (Wiler et al. 2009). Thus, inefficient patient outflow is an important and urgent issue that needs to be addressed.

Previous research on ED patient flow largely investigated the efficiency of patient inflow (Derlet et al. 1992, Holroyd et al. 2007) and emergency patient care (Cowan and Trzeciak 2004). For example, Solet (2006) investigated the barriers that impacted effective clinical handover during patient admission. There has only been a paucity of studies on patient outflow. For example, Winthereik and Vikkelsø (2005) explored how a semi-structured discharge letter served as both an informational tool and accounting device when the hospital handed a patient over to the patient's general practitioner. Since inefficiencies and breakdowns in the outflow processes can result in bottlenecks, it will in turn affect the overall efficiency of patient flow. More recently, Abraham and Reddy (2010) studied a specific kind of ED patient outflow – admission to an inpatient unit in the same hospital. They identified challenges in coordinating activities within a department and between departments that were crucial for patient admissions. They also reported challenges in coordinating in-house clinical and non-clinical stakeholders and activities for patient admission. Yet, this study only focused on the coordination activities within the same hospital. Our study in contrast looked into coordination activities with a variety of stakeholders of different organisations. We also highlight the importance of non-clinical collaborative work, which was not currently supported in health information systems, in achieving efficient patient outflow.

In the current investigation, we conducted an observational field study to investigate patient outflow in the ED of a large urban teaching hospital in North America. The goal of our study was to acquire a better understanding of the activities and processes associated with patient outflow, and if and what challenges were present that might impede its efficiency. Given the time-critical nature of most ED patients' illnesses, any inefficiency that directly impacted patient outflow could jeopardise the care of current patients (ACEP 2007) as well as that of prospective patients who needed emergency care at the ED (IOM 2006). In our study site, inefficient patient outflow not only led to overcrowding in the ED because patients could not be admitted to the ED, but it also affected the operation of other medical units and that of other organisations such as insurance companies, medical equipment suppliers, and nursing homes. Therefore, problems that emerged from inefficient patient outflow were not localised in the ED; intra-organisation and inter-organisation coordination and collaboration could be affected as well.

Our study revealed that ED patient outflow required intricate coordination among a variety of stakeholders such as in-house physicians, social workers, porters, insurance company representatives, and physicians or representatives in external facilities to which patients were to be transferred. These stakeholders have to utilise varied communication mechanisms, information artefacts, and be involved in a diverse set of activities. These coordination efforts thus formed a web of operations required for achieving patient outflow. In our study ED, case managers were responsible for this web of operations to facilitate and expedite patient outflow, and consequently the overall patient flow in the ED. Thus, the overcrowding issue was largely contingent on how efficiently the multiple, concurrent, and intertwined patient outflow processes were managed.

This study also provided implications for future design of health IT systems, in particular the electronic health record (EHR) system. It is generally believed that an EHR can potentially increase the efficiency of patient care. However, we found that its use was limited when addressing the inpatient boarding issue, partly due to its inability to support many non-clinically driven, yet critical, tasks required in the patient outflow process. Although EHR systems have been criticised for being inadequate in supporting clinicians' work practices (Walsh 2004), these systems were intended for use by clinicians to facilitate patient care. Since coordination for ED patient outflow involved not only clinical work but also a variety of non-clinical work (Abraham and Reddy 2010), the current design of information systems thus fell short in supporting the non-clinical work that was vital for patient outflow.

Our findings highlighted the complexity of coordinating patient outflow with heterogeneous external stakeholders. The inherent autonomy of individual organisations and the lack of shared organisational goals and communication channels rendered it more challenging for ED personnel to maintain awareness for coordinating communications and activities. Hence, the current research offers new insights into the challenges of coordinating cross-organisational activities among a diverse set of stakeholders.

Our research makes several contributions. First, we contribute an in-depth understanding of the coordination work in patient outflow and how the current health information system failed to support this coordination work. Second, we contribute insights into how patient outflow may influence overall hospital operations and inter-organisational operations. Third, we contribute sociotechnical design implications for supporting the coordination work to facilitate patient outflow. Finally, we contribute improved knowledge to the human computer interaction (HCI) and computer supported cooperative work (CSCW) scholarship on collaborative work in complex systems and high-reliability organisations.

Background

A fundamental intellectual challenge in designing a collaborative system lies in the social–technical gap between the need to support the highly flexible, nuanced, and contextualised social world and the difficulty of making technical systems flexible in support of such a social world (Ackerman 2000). Thus, a wealth of research has been conducted in a variety of complex sociotechnical systems to investigate how collaborative work was coordinated and carried out with different stakeholders. For example, in-depth investigations in an underground transportation control room (Heath and Luff 1991) and an aircraft operations room (Goodwin and Goodwin 1996) revealed how co-located collaborative work was carried out in high-reliability domains. These studies identified the importance of maintaining workplace awareness and performing timely and situated actions for achieving optimal use of available resources in complex collaborative work environments. Similarly, as case managers, the personnel who are in charge of patient outflow in the ED must constantly assess and rearrange outflow tasks for multiple patients at the same time; such assessment and re-arrangement become a highly situated process. It requires tacit knowledge and hands-on experiences that must be gathered in practice, as well as knowledge in standard operation policies and procedures. Thus, the required coordination tasks have to be performed with 'the view that every course of action depends in essential ways upon its material and social circumstances, rather than attempting to abstract action away from its circumstances and represent it as a rational plan . . . to achieve intelligent action' (Suchman 1987, 50). Thus, situated action provided a different lens to guide the analysis of collaborative work not only in the context of tangible factors like formal work protocols, but also in the context of implicit and embedded work practices, for example, as a factor of cultural, social, or historical constraints (Suchman 1987). The complex work environment of an ED renders the need for culturally, socially, and historically appropriate activities to be carried out, similar to how activities were performed in the aircraft operations control room (Goodwin and Goodwin 1996).

While these previous studies provided useful knowledge on how collaborative work was achieved through carefully coordinating a large number of tasks and communicating with many different stakeholders, they largely centred upon a designated set of stakeholders. In contrast, the ED patient flow coordination work typically requires frequent and dynamic communications with a diversity of co-located and distributed stakeholders with varying needs, expertise, protocols, and work practices. In addition, the emergent and time-critical nature of most ED cases makes the patient flow coordination more challenging and complicated. Therefore, the intricate patient flow coordination work in the ED becomes an ideal setting for studying collaborative work behaviours and the complex coordination work. In particular, studying how case managers coordinate patient outflow serves as an interesting example for understanding the roles of key coordinating personnel in a complex and dynamic sociotechnical environment.

In healthcare, a variety of sociotechnical issues have been considered crucial to work collaboration and coordination. For example, temporality plays an indispensable role in all collaborative work as the knowledge and experience of temporal features are often taken into consideration for planning, organising, and executing work (Reddy and Dourish 2002). As such, different temporal structures among team members of a patient care team (e.g. physicians, nurses, pharmacists) were found to be highly challenging for coordinating care-related activities (Reddy, Dourish, and Pratt 2006). Similarly, mobility and spatiality were also key issues to team collaboration in patient care (Bardram and Bossen 2003, 2005). Collaboration

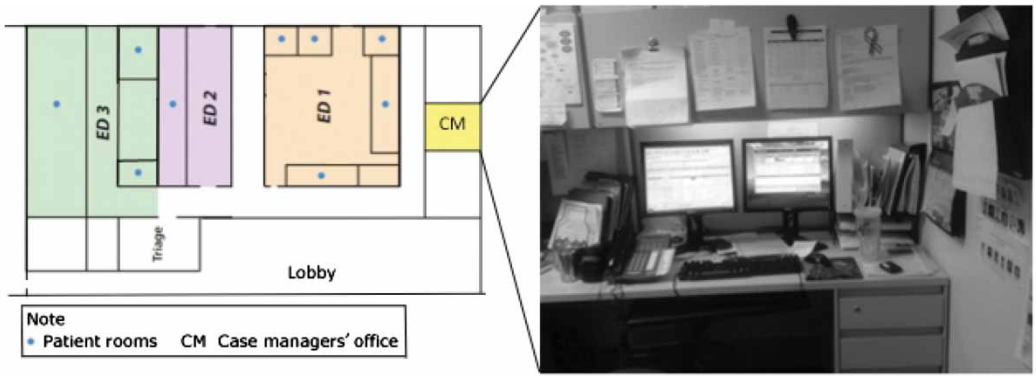

Figure 2. (left) Layout of the ED, (right) the case managers' office.

breakdowns were found to impact patient care when treatments involved health professionals from multiple medical units (Benham-Hutchins and Effken 2010). Even within a single team, clinicians were often required to engage in multiple patient cases through collaborating with multiple distributed care teams simultaneously (Lee et al. 2012). Yet, these previous studies mostly focused on challenges of collaborating with clinical team members, whereas the current research investigated patient care efficiency on a broader operation level of the entire ED.

Methodology

We conducted an observational study in an ED to acquire a better understanding of how patient outflow was carried out. The knowledge gained was used to help inform the design of information technology for improving patient outflow, which would in turn help facilitate the overall patient flow in an ED.

Study site

Our study site is the ED of a large urban teaching hospital in North America that serves patients of a wide range of socio-economic statuses but mostly with health insurance. It is also a typical ED setting where overcrowding is an issue. The ED consisted of three units to serve patients of varying levels of severity (Figure 2, left): ED1 had 16 beds for patients with life-threatening or traumatic medical problems, ED2 had seven beds for moderately ill patients, and ED3 had nine beds for mildly ill patients. The case managers' office, located inside the ED, is equipped with a computer with dual monitors (Figure 2, right).

Participants

Our participants were initially physicians, nurses, social workers, and patients in the ED. We shifted to shadow and interview the case managers working in the ED after recognising the crucial role played by case managers in patient outflow. There were four case managers working in the ED, all female aged between 40 and 50, each having more than five years of experience in both nursing and case management. Two of them work full time on 12-hour shifts (morning or night shifts). The other two, a casual case manager and a case management director, are reliefs who only work when the full-time case managers are absent. Only one case manager is on duty at any given time in the ED. A case manager typically handles 8–12 patient outflow cases at any point in time.

Data collection

A total of 110 hours of observations was conducted at the ED over six months in 2012. In the first two months, we spent 40 hours in observing 12 complete ED patient cases from the patients' arrival to their departure, followed by 70 hours of shadowing the four ED case managers over four months. Altogether we acquired a better understanding of the patient outflow process.

This paper primarily reports findings from the 70 hours of shadowing, during which we observed complete and partial cases that often took place concurrently. Shadowing of the case managers took place in early mornings till late evenings on both weekdays and weekends. Each observation session ranged from two to six hours. We also conducted formal interviews with two case managers; each lasted approximately 1.5 hours, to gather their opinions and perceptions on the ED's patient outflow work and their role in the outflow coordination. The interviews were audio-recorded and transcribed for data analysis.

In addition, informal interviews, which were mostly for elaboration or clarification of the participants' actions, were performed whenever necessary and feasible. Handwritten notes were recorded for all the observations and informal interviews, and were later transcribed for analysis.

Data analysis

The transcribed data were first analysed using various diagramming methods such as communication diagrams and flow diagrams (Beyer and Holtzblatt 1997) to understand

the activities in the ED outflow process. We then used grounded theory (Strauss and Corbin 1998) on both the observational and interview data to iteratively identify emerging themes such as types of activities or events, activity locations, technology or artefacts used, stakeholders involved, and challenges encountered. In particular, affinity diagramming (Beyer and Holtzblatt 1997) was used to organise the themes in the data analysis process. Breakdowns and bottlenecks in the patient flow, particularly in the outflow, were also noted. The identified themes were subsequently refined through feedback from peer researchers.

Findings

In our study, we acquired an in-depth understanding of how patient outflow processes in the ED unfolded. Specifically, we identified that efficient patient outflow required careful and timely coordination and collaboration of heterogeneous stakeholders to engage in a variety of time-sensitive and interwoven activities and interactions. In this section, we first present an overview of the ED patient outflow process in our study site. We then present the challenges encountered in cross-boundary communication for achieving efficient patient outflow. In particular, we identified challenges that emerged from both intra-organisation and inter-organisation coordination and collaboration for patient outflow.

ED patient outflow

Our study site, a typical ED, primarily serves patients with acute illnesses and injuries that require immediate medical assistance. It is thus not intended for long-term or continuing care. In fact, its operation hinges upon whether patients can be efficiently purged from the unit when they no longer require emergency medical care. Below we describe a typical patient care scenario at the ED. All the scenarios described in the paper were extracted from our observation notes and interview recordings. The names have been altered to preserve participant confidentiality.

> Due to sudden intense chest pain, Steve went with his wife to a nearby ED. After an initial examination and close monitoring, Karen, an ED physician, decided that Steve's condition was rather severe and he should be admitted to the intensive care unit (ICU). Without further delay, Karen entered an admission request in the electronic medical record (EMR) and paged the case manager on duty of the request. Lora was the case manager on duty. As soon as Lora noted the urgency of the request, she called Steve's health insurance company for an authorisation on the admission. Over the phone, she explained the level of care that Steve needed, in the language and terminology that the insurance representative could understand. However Lora had to gather more information from Karen as the insurance representative demanded specific details for identifying the appropriate billing codes for Steve's condition before an authorisation could be made. Upon getting the authorisation, Lora physically located Karen, Steve and his wife to inform them of the admission approval. She then continued on to coordinate the patient handoff with the physicians and nurses in the ED and the ICU, as well as to organise porters for the admission when an ICU bed was available. Steve was then transported from the ER to the ICU.

This scenario illustrated one of ED patient outflow options: *admission* to an inpatient unit in the same hospital as Steve was medically unstable, thus requiring further treatment and care. Alternatively, a patient whose condition is stable but requires further care and/or treatment will be *transferred* to an external health facility that meets the patient's needs such as a nursing home, a hospice, or another hospital. Moreover, patients will be *discharged* when they are deemed medically stable to be nursed by themselves or by home care services. ED physicians make these decisions based on the patients' medical condition.

Discharging patients is generally straightforward by filling in a discharge note and the patients will leave the ED on their own. However, our study indicated that admitting or transferring patients was often complicated and thus required careful coordination among heterogeneous stakeholders and pertinent tasks. It is paramount that these coordination activities be handled properly. Otherwise significant delay in patient admission and transfer could result and lead to inefficient patient flow and resource utilisation. Thus, this paper focuses on patient *admission* and patient *transfer*. When, where, and how patients were transitioned out of the ED were determined by a number of factors such as the patients' and their families' preference, their health insurance coverage, and the bed availability in the receiving medical unit (e.g. the ICU) or external healthcare facility (e.g. a nursing home). Any inefficiency or failure in the transition process could lead to undue delay in a patient's stay, which also directly hindered the operation of the ED and impacted the use of ED resources.

Challenges in patient outflow: admission and transfer

To facilitate patient turnover in the ED, patient outflow must be carefully coordinated so that it does not become a bottleneck in the ED operation. The simplified scenario described above did not include many of the nuanced activities that were performed in the course of coordinating for Steve's admission. For example, Lora had to negotiate with the insurance representative back and forth a number of times, during which Lora also had to repeatedly seek information from Karen and Steve before an authorisation from the insurance company was obtained. Coordination with the ICU for the admission was not uneventful either. Lora had to actively communicate with the ICU clinicians and closely monitor bed availability in the ICU through the Bed Management System (BMS) in order to secure a bed for Steve without unduly delay. She also had to maintain constant communication with the ED physician and nurses, as well as Steve and his wife about the progress of the admission, to communicate with relevant personnel such as ICU physicians and nurses to arrange the admission and

to schedule the actual transportation from the ED to the ICU with hospital porters.

Challenges in patient outflow coordination

We found in the study that both intra-organisation coordination that was required for all admissions to an inpatient unit and inter-organisation coordination that was crucial for transferring patients to an external facility were challenging since they both involved a variety of medical units, facilities, work processes, culture, protocols, policies, and local practices. Although admissions are primarily concerned with coordination within a healthcare organisation and transfers rely heavily on coordination across healthcare organisations, they both entailed different degrees of intra- and inter-organisational coordination. Thus, admissions and transfers were found to share similar challenges. In the following, we present these challenges encountered in our study ED. These challenges were found to be largely attributed to the lack of shared operational goals and the lack of transparency in communication and coordination among diverse medical units and organisations involved in the patient outflow.

Lack of shared agenda and goals across medical units/organisations. Coordinating patient outflow is complex and challenging as it involves other medical units that are often guided by their own goals and are autonomous in their management and operations. Although shared organisational goals, structural hierarchy, and standard operating procedures (SOPs) are typically in place to guide individual departments' operations so that the departments can work towards the common agenda and goals, different departments often have their own concerns, priorities, and needs that may compete with those of other departments. For instance, while attending ED physicians were the ones to decide whether and when a patient is to be admitted to an ICU room based on his/her medical condition, in practice, however, when the patient could be moved out of the ED depends on a number of factors that might be beyond the control of the ED physicians. In addition to getting insurance authorisation, these factors included the readiness of the ICU with respect to the availability of a patient bed, a nurse, and an admitting physician in the ICU, documentation for the admission, and availability of hospital porters. The actual admission processes also involved a variety of non-clinical personnel such as janitors, case managers, and social workers. Thus, patient outflow processes often required extensive coordination work. Breakdowns could happen when required personnel and/or resources were not available at the time, which was also found in other studies (e.g. Bardram and Bossen 2005). When breakdowns occurred, case managers were often responsible for addressing the problems, as expressed by a case manager we interviewed, 'Really mainly what our job is figuring out what everyone else is doing wrong. That's basically what our job is and fixing it or being the communication person between every person that's not.'

Additional coordination challenges were observed when arranging patient transfer to an external facility as coordination must be conducted with external organisations. The fact that each organisation has its own missions and goals, local practices, and polices has made such cross-organisation coordination particularly challenging. To illustrate, conflicts often existed between insurance companies and healthcare institutions as the former typically aimed to lower their payout whereas the latter generally focused on providing best possible patient care which, however, could conflict with the insurance company's goal to minimise their payout. As such, repetitive negotiations between these stakeholders often took place so that the organisations could try to work together to work towards their respective organisational goals. The following verbatim quote was extracted from a case manager's phone conversation with an ED nurse trying to coordinate a patient case that was complicated by the patient's family dynamics, insurance coverage, and local protocols in hospices – a health facility specifically for terminally ill patients.

> This is a 34 year old female who has come dying … I guess a week ago she went to [Hospice A]. She was … with them for two days. Finally they 911 her to the hospital, revoked hospice and then they just decided to go on hospice for a couple days with [Hospice B] … They signed up last night. The mother accused the hospice [B] of trying to kill her daughter. They have 24 hour care. The mother … declined any medication and 911 back to the hospital and then they wanted [Hospice A] so [Hospice A] came out. The father just fixated on diuretic, just driven the doctors and nurses absolutely crazy, fixated with hospice and came back with all signed up for continuous care and everything is ready to go, the ambulance called. And then the [dad] threw away the paper work in the trash and wanted [Hospice B] again … He's an alcoholic. The mother is crazy so you know all these family dynamics … Now, [Hospice B] is backed out because the patient revoked hospice today, they can't admit this patient for 24 hours. Because when you revoke hospice, you can't re-admit to the same hospice on the same day.
>
> The case manager was asked to elaborate. Well actually when you are in the ER, … .it depends on what you're coming to the ER for. I worked in hospice for two years. So if you're coming to the ER for something other than your hospice diagnosis, then you're not revoking but she came in for what her hospice diagnosis is. Let's say you revoke at 11 o'clock at night and you want to go back to hospice the next day at 12:01, you can because it's a different day and it actually has to have a different date. You can't revoke a hospice and go back to the same hospice. Now if this patient wants to go back to [Hospice A] because they revoke [Hospice B] they could. But they can't go back to [Hospice B] for 24 hours …
>
> So … my thought was to admit her here as an obs [observation] and then have hospice take her tomorrow … The case manager was then redirected to call another person. That's ok, I'll call.

As indicated in this conversation, in order to solve the problem, the case manager had to talk to several different stakeholders including the ER nurse, a representative from Hospice B who had just arrived at the hospital for the

patient demanding an immediate answer, the bed manager, and finally another ER nurse working the night shift. For each conversation, the case manager had to first describe the case, in a way similar to the above quote. In the course of gathering necessary information for this patient case, the case manager had to constantly evaluate the information at hand and what further information is required for providing an optimal solution. As shown in this conversation, the best solution appeared to be keeping the patient in the hospital until midnight and then transferring the patient to the hospice, where terminally ill patients receive comfortable care and social support. This example showed that case managers have to constantly obtain, negotiate, evaluate, and plan for each patient case in order to achieve an optimal outflow that benefits both the patient and the ED operation.

Lack of chain of command and accountability across organisations. In an organisation, the hierarchical power and authority structure among different departments and personnel are often stipulated by its chain of command, function, and accountability, which thus play an important role in guiding intra-organisational communication, work coordination, supervision, and subordination. SOPs are also often used to steer intra-departmental as well as inter-departmental operations in an organisation. However, such hierarchical relationships do not exist with external organisations, making it more challenging to work across organisations.

In our study ED, the case managers were responsible for communicating and coordinating with external organisations. Without a clear chain of command, the case managers typically did not have the authority to 'instruct' or 'direct' the external stakeholders to cooperate or to comply with their requests. Thus, the case managers often encountered issues with external stakeholders who worked with their own agenda and at their own pace. For example, a nursing facility might locally decide that they would only admit patients during a particular time frame but such information was not readily available to the case managers or other parties outside this facility. In another situation, the nursing facility might only accommodate the request from the ED after satisfying requests from other more preferred healthcare institutions. Therefore, dealing with external stakeholders required flexible and dynamic adjustments to one's local work practices in order to fit into an external stakeholder' work practices, agenda, and routines. In this regard, the ED case managers were often found to learn from different informal sources about unpublicised local practices in different facilities so that they could more effectively coordinate the patient outflow.

Lack of transparency across boundaries. The current health information system in the hospital where our study was conducted did not provide any formal means for relevant stakeholders to communicate with one another. Instead, the ED case managers had to initiate communications explicitly with the concerned stakeholders, mostly through telephone, fax, or email.

For patient outflow, in particular, the coordination effort was generally achieved through trial-and-error since external organisations operated autonomously and their operations were not transparent beyond the organisational boundary. Moreover, given the lack of a shared communication channel among the heterogeneous stakeholders, coordination must be mediated and in our study ED, case managers mediated such communications. The case managers not only had to engage in active communication with various stakeholders, but were also responsible for relaying communication to pertinent stakeholders so that patient outflow information could be disseminated efficiently. For example, in the hospice case described above, the final transfer decision made by the case manager had to rely on appropriate and timely communication with multiple stakeholders, including the ED physician, the nurse, the insurance company, the hospice to which the patient will be transferred, the patient, and the patient's family who may be at different locations. In this case, the case manager also had to explain to the patient and her family that they would not be allowed to 'drop' any hospice for 30 days (more details will be described later).

In practice, additional rounds of information relaying often took place after iterative enquiries and negotiations with the receiving unit/facility for confirming the admission/transfer and the arrangement of transportation. Furthermore, domain-specific terminology and language used by different organisations also had to be appropriately translated and conveyed to the concerned stakeholders. However, since no standardised communication channel was in place in the current information system, stakeholders often communicated through different channels arbitrarily. For instance, a stakeholder could discretionarily communicate a transfer request through a pager, the EMR, or the BMS. Thus the case managers were found to have to monitor all possible communication channels at all times.

Lack of awareness of bed availability. The BMS was available for checking bed availability at different inpatient units in the hospital. However, an external facility's bed availability could only be found out over phone, fax, or email. Hence, it was not unusual that several external facilities had to be contacted before an available bed was located. This problem got complicated when communication had to be conducted asynchronously such as through voice messages, which could lead to confusion and miscommunication during the coordination. To illustrate, after a case manager left a message on facility A's answering machine to request for a bed, she later called facility B before she received any response from facility A. Facility B confirmed the bed availability over the phone but at the same time facility A got the message and turned down

a request from another hospital in order to accept the case manager's request. The case manager then had to explain to facility A, which had to call back the hospital that they had just turned down. Thus, having no awareness of other facilities' bed availability could easily create problems and increase the workload of case managers and other external facilities in the process of coordinating patient outflow.

Lack of knowledge of local practices. As described above, local practices in a facility could impact patient transfers, which would in turn affect the ED patient flow. In our observations, we found that the ED case managers often had to call several external facilities to request for a bed for an ED patient until they found one that agreed to admit the patient. In one incident, the admission hours of the admitting facility has passed when a bed was located. The patient then had to board in the ED overnight until the next day. If the case manager had prior knowledge of such local practices, she would likely have contacted this facility earlier so that the patient could be transferred out in time. However, since such information was not publicly available and the case manager only found out when checking for bed availability, the patient outflow was unnecessarily delayed.

Similarly, in the hospice case, the case manager and the ED nurses initially thought that Hospice B was 'out of the [medical] network' so that the patient's insurance would not pay for her visit at this hospital. However, after asking several people including an ED nurse, the bed manager, a hospice representative, about the case, she learned from the last person she called, an ED nurse working the night shift, that the medical group the patient belonged to was actually not 'out of the network'. Therefore, the patient could be admitted to the hospital on observation and then admitted to the hospice that the patient's family wanted the next day. If the case manager had known about this, she would not have had to contact so many stakeholders for the case. She also found out informally that when a patient revoked from a hospice, the patient would be 'dropped' from the medical group for 30 days during which the patient could not revoke a hospice again. Therefore, the case manager had to explain this to the patient, which turned out to be challenging given the specific family dynamics of this patient. These examples pointed to the need for a shared system with information on local practices, as it would be useful in facilitating patient transfers.

In fact, case managers also have to possess tacit knowledge about work policies, routines, and culture of many frequently used external facilities so that they can choose an optimal patient outflow plan without unnecessary delay. For instance, in an interview, a case manager told us how she worked with financial institutions. Since most banks close at 5 pm, some tasks being carried out before 5 pm and some after 5 pm may vary as the case manager cannot contact the banks to request financial assistance after hours. Therefore, she always tried to put requests in earlier as she knew that some cases would take longer to complete. Similarly, case managers have to be aware of subtle issues of other facilities, such as what day/time they close and if the staff will be available during lunch breaks, so that making transfer requests to these facilities will be uneventful. These seemingly trivial issues can dramatically change the way that a patient case is handled, which also impacts how soon a case manager can complete a patient case.

Use of domain-specific terminology. Stakeholders involved in patient outflow typically have different expertise and protocols that were used to guide their evaluation and decision of patient cases. They thus required information that was understandable within the scope of their own profession so that they could make informed decisions. For example, Lora in our scenario had to translate clinical terminologies into corresponding terms understandable by the insurance representative over the phone so that the latter could make informed decisions. Similarly, she also communicated lengthy insurance policy to Karen in a succinct and concise manner, particularly when the medical diagnosis did not align well with the standardised insurance billing codes. In addition, case managers often helped patients and their family and caregivers to understand relevant medical knowledge such as diagnosis, treatment, and care options by translating them into layman's terms.

In some situations, information gathered from multiple stakeholders must first be synthesised before disseminating to others. For example, an admission request submitted by an ED physician for a patient with acute coronary syndrome might only consist of his medical assessment, diagnosis, and treatment plan, which then had to be translated into an appropriate level of care stipulated in the insurance company policy, as well as the maximum medical costs that the insurance company would pay. In this way, the insurance company would have the proper information to make the decision. In addition, a variety of government agencies and third-party facilities may also be involved in patient transfer and require information translated into their domain language so that they could make informed decisions.

Challenges in managing multiple simultaneous patient outflows

Of no surprise, task coordination would get more complicated when there were multiple simultaneous patient outflows. Dealing with multiple outflow cases simultaneously was challenging as it required not only the execution of tasks necessary for individual patient outflow but also constantly prioritising a multitude of interwoven tasks required for the multiple, often varied, patient outflow cases. In practice, these interwoven tasks had to be constantly juggled, particularly when new tasks emerged from existing or new outflow cases or when an incomplete task impeded the execution of subsequent tasks. In

the following scenario, we provide additional activities that were performed in Steve's admission described above to show that multiple patient transitions took place simultaneously when Lora received the admission request from Karen, the ED physician.

> Lora was talking on the phone with an insurance representative for another patient, David, regarding his transfer to another health facility when Steve's admission request reached her pager. Lora noted the urgency for Steve's admission so she quickly jotted down the list of medical facilities and ambulances contracted with David's insurance company. She then looked up Steve's EMR to see why he should be admitted to the ICU. After assessing the admission request, Lora called Steve's insurance company and obtained an admission authorization after back-and-forth phone conversations. Next, she called one of the contracted facilities provided by David's insurance company, and faxed his medical information to this facility for evaluation and charting David's case in the EMR system. When Lora was just about to arrange Steve's admission, an ED nurse came to ask for help regarding a patient discharge because this patient could not afford an oxygen supply equipment that he needed for home care. Given Steve's acute condition, Lora told the ED nurse that she would get back to her later and continued to arrange Steve's admission through requesting a bed in the BMS (bed management system). Afterwards, Lora retrieved a social worker's number from her paper notebook and called to inquire about a welfare program for this patient. Then Lora went to inform the to-be-discharged patient and his nurse about the welfare program. Upon getting back to her office, the facility she contacted earlier for David's transfer called to inform her that they could admit David. She quickly jotted down the contact information for this facility and gave it to the clinical staff in charge of David's case to get ready for the patient handoff. She also called to arrange an ambulance pick-up. At the same time, Lora received a notification in the BMS that Steve's bed in the ICU was ready. Lora thus arranged to have a hospital porter to send Steve to the ICU.

Our study found that there were typically 8–12 patient outflow cases at any time in the ED but it could vary considerably. For example, 'if it's not a busy day, I [the case manager] just sit with them (ED physicians and nurses) for a bit, just to observe the process. 'Cause I am a visual person, so I'd rather just see how it works . . . otherwise I just go from here to there'. At other times there might be excessive number of cases.

> There're a lot of bed requests today. There is another one . . . so it hasn't been like crazy, you know, out of control busy . . . When I was at lunch, about 6 of them came in. So that's my business . . . there are 1,2,3, . . . 15 admissions! That's pretty busy for 1:15 in the afternoon.

Each patient case often consisted of different and multi-stage work tasks that had to be performed sequentially and/or concurrently, as illustrated in Figure 3. It should be noted that the case shown is a simplified patient transfer

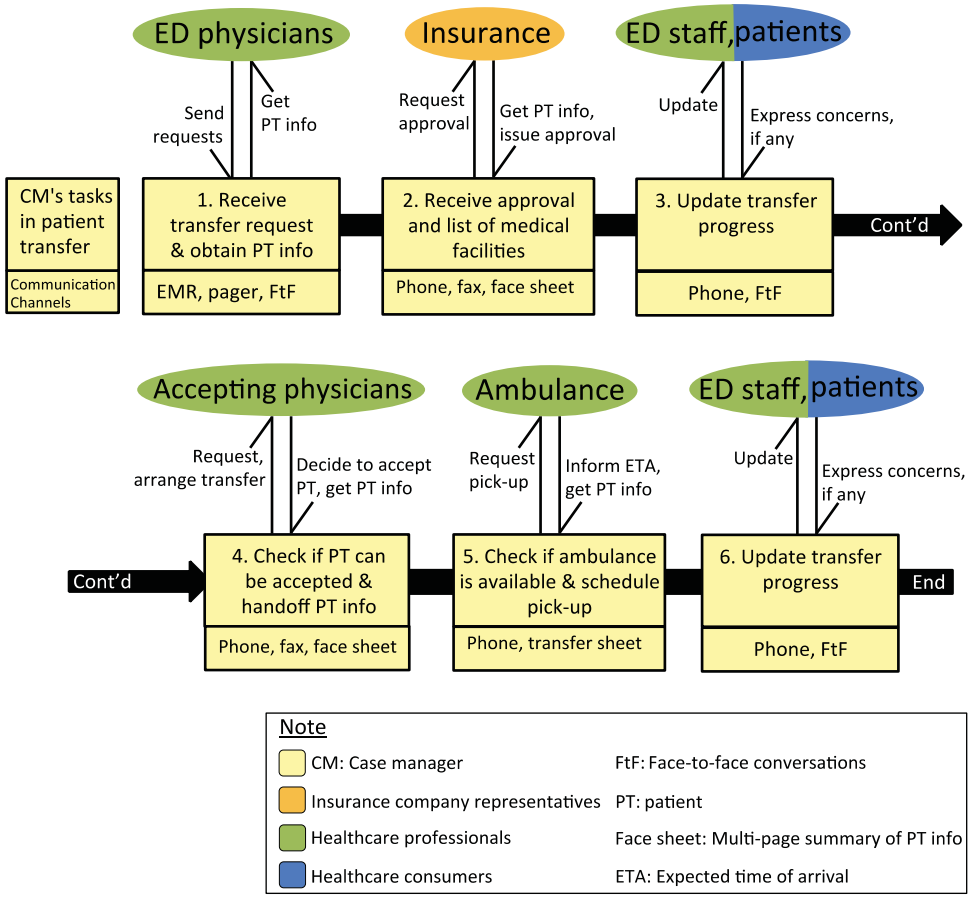

Figure 3. Patient outflow coordination activities involved in a single patient transfer.

process only to indicate the key processes and in reality, each process in the diagram could involve multiple rounds of communications and/or negotiations. Thus, dealing with multiple patient cases was complex and highly challenging with many heavily interlaced work processes. The complexity of multiple patient outflow cases can also be visualised by overlaying a series of similar timelines as shown in Figure 3, except that the overlaid timelines are composed of events taking place at different time points. Thus, in order to achieve efficient patient transitions out of the ED, co-located and distributed stakeholders had to collaborate synchronously and asynchronously.

On the other hand, case managers often have to proactively look for patient cases to ensure efficient patient outflow from the ED, especially when the waiting room was full and the ED patients were ready to be transferred. This is because information about the ED operation was not readily available to the case mangers. In fact, sometimes the ED nurses were too busy to relay these 'transferrable patient' cases to the case managers. For example, a case manager said, 'I go around the ER several times a day, "is there anything I can help with?" Cause some times they forget that we are here.' These quotes reveal that there is a lack of effective protocols to manage the interrelated tasks involved in patient flow. Thus, the baton may drop when everyone is busy with emergency patient care and when the case managers' critical role in patient outflow is overlooked. As such, new ways of providing awareness of the patient flow for the case managers and the availability of case managers for facilitating patient outflow are essential for the ED patient flow.

Discussion

Our study revealed that the outflow coordination work was challenging, particularly in coordinating patient transfer. This was mainly because the health information technologies available in the ED, such as the EMR and BMS, only supported clinical work but not the non-clinical work, which was found to be among the key barriers for coordinating patient outflow at the ED. Our study also demonstrated that the efficiency and productivity of an ED hinged upon its patient outflow. Therefore, in the following, we discuss a critical, yet often unsupported work in the current information systems design – the invisible non-clinical work in patient outflow coordination. We also discuss its impacts on the overall efficiency of the ED.

The role of non-clinical work in patient care efficiency

Efficiency in patient care has been a primary measurement of quality in health practice, particularly in EDs, which serve as the entry point to many inpatient admissions. Efficiency in patient care is based on whether sufficient resources are available for patients in need and whether patients could receive quality patient care in a timely manner. While breakdowns can occur at any point in the ED patient flow and can adversely impact the efficiency of the operation, our study indicated that bottlenecks largely existed in the patient outflow when patients could not be moved out of the ED efficiently due to a number of factors. These factors were primarily non-clinical, such as unavailability of inpatient beds, failure to locate an external facility, long wait for transportation, or extended negotiation with the insurance company for authorisation. Inefficient patient outflow, however, has negative implications: patients cannot be admitted to the ED efficiently, the limited resources available are sub-optimally utilised, and the efficiency of the overall patient flow is greatly hampered. Therefore, the non-clinical work required for patient outflow was found to be the key barrier to patient care efficiency and optimal utilisation of clinical resources.

The ED efficiency relies not only on clinical work involved in patient care, but also on non-clinical work for patient outflow coordination. While collaborative work in healthcare has been well studied and documented, the role of non-clinical work in patient care efficiency has not been given much attention. With limited clinical resources available in the ED, and in healthcare more generally, it is ever more important to ensure that non-clinical work does not impede the patient flow. Instead, non-clinical work should be better supported to help facilitate patient flow.

The current information system in the study ED, however, did not adequately support non-clinical work. For example, despite using the BMS to check for bed availability, ED case managers still had to personally negotiate with the bed manager of the corresponding inpatient unit after submitting the bed requests in the BMS. Moreover, the disparate BMS and EMR systems required manual transfer of medical information from one system to another. For example, making a bed request in the BMS required the patient's medical information for justification of the admission. However, the patient's medical information was only available in the EMR system and thus had to be manually copied to the BMS as they were two standalone systems in the current system's design.

For patient transfers, our study has shown that the challenges faced in their coordination were multifold as heterogeneous stakeholders with varied goals, agenda, culture, policies, and local practices were involved. Moreover, there was no IT support available to facilitate the communication with external organisations for tasks like checking availability of patient bed and medical equipment, and finding out local practices of the external facilities that might have an impact on the patient transfer. An example was described in the paper on how the locally predefined admission time frame of a nursing facility led to the patient boarding in the ED and suboptimal use of the ED resources.

Clearly from our study, the non-clinical coordination work was not supported in the current information system. Without a proper statement in the information system, such non-clinical work has become invisible to the frontline

operation and personnel, and also seems to have obliviously drifted to the backstage. Yet, as our study has shown, patient outflow and the overall patient flow in the ED could potentially be facilitated through efficient execution of the non-clinical coordination work. Hence, as suggested by Suchman (1995), it is high time that invisible non-clinical work was brought to the forefront. This can be done by providing integrated support for both clinical and non-clinical work in the information systems design for supporting the collaborative work.

The current research thus contributed additional knowledge on the complex patient outflow coordination process that consists of intertwined clinical and non-clinical tasks. Our study also shed light on the ripple effect of inefficient patient outflow as a result of the lack of IT support for non-clinical work in the current information system, which in turn led to inefficiency in the overall patient flow in the ED. This work is important as it provides additional insights for mitigating the prevalent overcrowding problem in most EDs.

Managing temporality at both individual and operation levels

As previously stated, the ED overcrowding issue is best resolved by managing patient outflow since patient inflow is often hard to control as most ED patient arrivals are unplanned and spontaneous. The trajectory of patient outflow is tightly associated with the temporal structure of the non-clinical coordination work, which again depends on how efficiently the coordination work can be carried out.

Temporality has been widely discussed in the HCI and CSCW literature as a key factor in collaborative work practices (Abraham and Reddy 2010; Reddy and Dourish 2002; Reddy, Dourish, and Pratt 2006). For instance, work coordination must take into account individual temporal horizons as well as collective temporal rhythms of multiple personnel (Reddy and Dourish 2002). However, these previous studies only investigated temporality of an individual task with regard to the collaborative patterns of all involved stakeholders. In contrast, our study focused on the interaction of multiple threads of sequential and concurrent work tasks in the context of large-scale operational efficiency of an entire department.

As pointed out by our study, patient outflow work often comprises tasks that must be performed sequentially such that delay in one task will deter the execution of the remaining tasks, and may consequently lengthen the outflow of a patient or even the overall patient outflow in the ED. This delay will eventually impact the chained operations in patient flow, and may lead to overcrowding in the ED. In addition to the temporal structure of an individual patient case, we also studied the temporal interweaving of the coordination work among multiple stakeholders, which to our knowledge has not been reported in prior literature. The efficiency of the ED operation is not determined by a single patient case only, but is determined by the efficiency of overall patient outflow, for example, 8–12 patient cases concurrently in our study ED. The intertwining nature of multiple cases undoubtedly makes the temporal coordination of patient outflow work more complicated and challenging. As shown in the second scenario in the findings section, the case manager had to constantly evaluate the statuses of all the active outflow cases, and keep prioritising and re-prioritising the tasks to make sure patients were efficiently transitioned out of the ED. For instance, if a patient case was delayed, a case manager might decide to first process other new cases so that the turnover in the ED would not be hindered by a slow-progressing case.

It seems plausible to propose constant evaluation of the temporal progression of patient outflow to help identify bottlenecks and delays so that they can be quickly rectified. However, manual evaluation without technological support can be daunting. In fact, it can become so overwhelming that the manual evaluation process itself becomes the bottleneck of the patient outflow.

Situated practice in coordinating patient outflow

Patient outflow is inherently situated in the larger social and cultural context of the entire patient flow and is thus tightly linked with a number of social factors, including the number of patients demanding emergency medical care, occupancy in the ED, and the type and complexity of outflow transitions. Therefore, the outflow coordination tasks had to be constantly reprioritised and rearranged based on not only the formal work procedures and protocols but also tacit knowledge and informal rules similar to the knowledge of the restrictive admission time frame described above. Such tacit knowledge, for instance, can be the understanding of certain medical facilities' practices, insurance companies' preferences, and patients' economic and social situations. In essence, the outflow coordination work is conducted within a complex sociotechnical system, in which the use of tacit, informal rules may help expedite the outflow process.

Design implications

As found in our study, the fact that patient outflow often involved different number and types of stakeholders, varying complexity of medical problems and care plans, as well as tasks in different stages and at different paces made task prioritisation particularly challenging. Thus, in practice, the interwoven tasks required for achieving efficient patient outflow had to be carefully and manually coordinated temporally, dynamically, and spontaneously. In this regard, technology would be a good candidate to provide support for managing the interwoven work processes.

Hence, we propose two design implications for supporting case managers' work in the ED. First, the case managers' work, though important, is not supported by

the current IT systems deployed at the ED. Besides, the case managers' indispensable role in the ED patient flow is often oblivious to other ED personnel. Together with the lack of an awareness of an overview of the ED operation, the case managers often have to proactively identify patient cases in the ED that they can handle to expedite the patient flow. A case manager suggested that a system that offered a visual display showing the overall flow and operation of the ED would greatly help facilitate and coordinate concurrent outflow activities. Similar electronic case handling systems have been explored using the metaphors of 'piles' and 'tiles' to show the operation overview and to help visualise the case workload (Blomkvist et al. 2004). However, these system designs failed to support cases that are interrelated and spanning multiple case managers. Thus, we propose technological support that offers an awareness system with visual representations of temporally ordered outstanding tasks for individual patient outflow as well as all the outflow cases in the ED. The system also shows the progress of the operation such as the number of patients in the waiting room and patients waiting to be transferred to an inpatient unit or an external facility. Such feature can help case managers prioritise the pertinent tasks. The system can also be used to issue alerts and reminders for time-sensitive tasks.

Second, case managers' work often relies on tacit and informal knowledge acquired through their interactions with different stakeholders in their daily work. For example, a case manager would likely schedule her work accordingly when she learned that a particular medical facility would not take patients during a certain time frame. This kind of informal knowledge is critical, but currently it is not shared among all case managers. It is thus important to promote a community of practice among the case managers for them to more easily share and document their acquired informal knowledge for review and reuse. The community of practice can also benefit new case managers who can then jump start their case management work based on the local knowledge in the repositories. Such organisational memory is useful to ensure the quality and continuity of practices in an organisation (Ackerman and Mandel 1995). We thus propose an integrated knowledge-based application in the information system to capture past encounters of the situated work for sharing and later retrieval. The system should also issue alerts for changes to the knowledge.

Limitation of the study

This research has several limitations. *First*, we have only examined case managers' work practices in a single field site. It is possible that case managers' work in other EDs or other medical facilities is different from our field site. Nevertheless, we believe that the insights identified in our work, such as the complexity of coordination work, autonomous nature of stakeholders, and temporality of interweaving tasks, portray the intricacy of case management, that allows us to understand the complexity and interlocked nature of work coordination in time-critical workplaces. *Second*, since case managers' practices are connected with many external stakeholders such as insurance companies and external facilities, it would be ideal to study both sides of the collaboration so as to fully understand the complex work practices. However, we were not able to shadow activities outside this field site, due to difficulties in obtaining field access and ethical approval.

Conclusion

In our study, we acquired an in-depth understanding of the patient outflow processes in the ED and identified that efficient patient outflow required situated coordination and collaboration of heterogeneous stakeholders involved in a variety of interwoven tasks. We also identified the challenges in both intra-organisation and inter-organisation coordination for patient outflow.

Our study provided important insights for supporting coordination work in complex sociotechnical environment such as the ED where the current study was conducted. In particular, we pointed out the need to make the non-clinical coordination work visible and be supported in the information system as efficient outflow can help facilitate overall patient flow. We also discussed how technology might be used to support the temporal coordination of the outflow work activities. We further proposed designing technological solutions to support the situated outflow coordination work by capturing tacit knowledge of local practices and informal protocols in external stakeholder organisations.

Our future research includes investigating entire patient cases encompassing the collaborative work conducted in the inpatient units and external facilities in preparation for patient transfer from the ED. The goal is to acquire a comprehensive understanding of the overcrowding problem and add to existing knowledge on the interplay between the inflow and the outflow work. Although the issues we identified in the study are typical to ED practices where overcrowding has been cited as a main issue in ED patient flow (Asplin et al. 2003; IOM 2006), the importance of proper case management and outflow management is not confined to ED care. Equally important to inpatient units as well as many fields beyond healthcare such as insurance companies, banks, and tax offices (Blomkvist et al. 2004) is managing resource utilisation and workflow in order to avoid bottlenecks and inefficiencies.

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