An Observation Tool for Studying Patient-oriented Workflow in Hospital Emergency Departments*

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Summary
Background: Studying workflow is a critical step in designing, implementing and evaluating informatics interventions in complex sociotechnical settings, such as hospital emergency departments (EDs). Known approaches to studying workflow in clinical settings attend to the activities of individual clinicians, thus being inadequate to characterize patient care as a cooperative work. Objectives: The purpose of this paper is two-fold. First, we introduce a novel, theory-driven patient-oriented workflow methodology, which better addresses the complex, multiple-provider nature of patient care. Second, we report the development of an observational tool and protocol for use in studies of this type, and the results of an evaluation study.

Methods: We created a tablet computer implementation of an instrument to efficiently capture patient-oriented workflow, and evaluated it through a field study in three EDs. We focused on activities occurring over time during a single patient care episode as well as the roles of the ED staff members who conducted the activities.

Results: The evidence generated supports the validity, viability, and reliability of the tool. The coverage of the tool in terms of activities and roles was satisfactory. The tool was able to capture the sequence of activity-role pairs for 108 patient care episodes. The inter-rater reliability assessment yielded a high kappa value (0.79).

Discussion: The patient-oriented workflow methodology has the potential to facilitate modeling patient care in EDs by characterizing both roles and activities in sequence. The methodology also provides researchers and practitioners a more realistic and comprehensive workflow perspective that can inform the design, implementation and evaluation of health information technology interventions.

1. Introduction

Workflow studies are mechanisms employed to characterize and study actual work situations [1]. Workflow is an abstraction that is particularly useful to characterize the procedural aspects [2] of organizational processes and provides a systematic accounting for how the work is conducted [3]. In manufacturing and office environments, the workflow may be denoted as “object-oriented”, meaning it was defined with respect to the product or service that is the output of the enterprise such as an assembled car or an insurance policy [1]. However existing object-oriented workflow methodologies in manufacturing and office environments lack the capability to depict the dynamic nature of activities driven both by protocol and by professional judgment.

Workflow studies in health care are typically clinician centric (i.e., subject-oriented); for example, focused on a nurse's workflow [4, 5] or a physician's workflow [6]. Although studying workflow from a subject-oriented, clinician perspective is useful for the purpose of improving individual jobs, the clinician-oriented approaches do not permit full characterization of complex work procedures in which many individuals with different skill sets undertake related and interdependent activities. This type of work is better characterized as “cooperative work” [7] and therefore requires workflow methodologies sufficiently broad and robust as to capture all salient aspects of the cooperative work.

A few studies such as Laxmissan et al. [8] and Puentes et al. [9] modeled workflow including multiple clinicians. However, their workflow representation is generic and static. They described either typical cases or an average situation. Although they may incorporate some common deviations, details such as the frequency of these deviations are not included. Developing workflow for actual individual patient episodes may be a solution to capture true workflow which is situational and emerges from the context.

Studies focused on implementation of health information technologies repeatedly reported that if the workflow is not well understood as the result of cooperative work during the design and implementation, the technology can disrupt patient
care and degrade patient outcomes [10–12]. The computer supported cooperative work (CSCW) literature highlights the necessity of considering multiple professional perspectives to understand complex group behavior [13]. As Pratt et al. (2004) defined “workflow reflects the processes that an organization has created to coordinate the activities of different individuals, to ensure the successful completion of work.” This definition highlights the importance of including multiple individuals in a meaningful context. Similarly, the distributed cognition literature highlights that work is not the sole property of the individual rather it is “stretched” across groups and other work elements such as material, artifacts, and cultures [14–16].

Horsky et al. [17] found that the cause of many delays, inefficiencies and opportunities for error in care delivery settings were the product of failures in interaction among human and other system agents. They also found that if information technology was not integrated well into the workflow, the result was often task duplication or suboptimal task division. The quality, efficiency and safety of health care depends heavily on how well people work together in clinical settings, and is no where more important than in highly acute hospital emergency departments (EDs) [18].

In EDs, care is delivered to a patient by nurses, physicians, technicians and others who work together to stabilize patients with life-threatening injuries or illnesses, and to treat patients with more minor problems. The distributed and contingent nature of patient care in EDs requires effective cooperative work between staff members, who are from multiple disciplines, with vastly different training and professional missions [19, 20].

A care group is formed when a patient arrives in an ED and the group dissolves when the patient leaves [18]. A single patient is the foci of a patient care group. Any staff member can be a member of multiple patient groups simultaneously [21, 22]. Group members organize themselves to meet the needs of a patient using technical (e.g. physical environment, information tools and technologies) and social resources (e.g. rules, procedures and professionals). The responsibilities, decisions and patient information for each patient are scattered across multiple staff members in order to augment capacity, combine specialties and integrate individual perspectives and heuristics [23, 24].

Direct field observations aid in study workflow in clinical settings. They are valuable because they offer an opportunity to capture the phenomena in context. Observations are even more useful when combined with other methodologies and can contribute to the early stages of system development cycle [17, 25]. Known workflow observation methodologies in clinical settings typically propose shadowing a single type of clinician [5, 6]; as a result, the observation tools were designed and are useful to study a single clinician and afford intensive documentation of individual clinical behaviors and therapeutic encounters. Clinician shadowing has the advantage of illuminating individual clinical behaviors in substantial detail [26, 27]. However, they must be modified and extended to study workflow, which involves multiple clinical and other staff members.

The purpose of this paper is twofold. First, we introduce a patient-oriented workflow methodology which is different than dominant clinician-oriented approaches to study patient care in EDs. Second, we report the development of an observational tool and protocol for use in studies of this type, and the results of an evaluation study.

1.1 A Patient-oriented Workflow Methodology for Emergency Departments

Patient-oriented workflow defines and models health care delivery from the patient’s perspective and organizes the building blocks of work around the patient [28]. A concept analysis of workflow [29] revealed fourteen definitions of workflow used in the literature and identified the following building blocks of a workflow: 1) Attributes (being a part of a system, having a structure and being in a distributed environment); 2) Elements (documents, individuals, non-human agents, activity/task/steps and information); 3) Objectives (product/service, flow of components and running a process). Researchers typically focus on a subset of these building blocks and can define workflow differently by organizing the building blocks of workflow differently. For example, clinician-oriented workflow focuses on activities of individual clinician’s activities for multiple patients. As an alternative, we propose to organize the study of workflow oriented around the patient, the focus of work. We call it the patient-oriented workflow methodology, which focuses on activities by multiple clinicians on individual patients. The unit of analysis is a patient care episode; therefore, workflow methods must characterize a range of activities undertaken by multiple staff members during a single patient episode. Workflow, then, provides an accounting of the key procedures and actors involved in the care of a patient during a care delivery episode; in the work reported here, the care episode encompasses the early stage of patient care in EDs.

The concept analysis [29] also provided us guidance to develop our patient-oriented workflow definition reflecting the cooperative, interdependent, dynamic-process nature of the clinical care process in the ED. For this specific study, we define workflow as a dynamic set of activities conducted on behalf of patients, the roles of individuals who conduct these activities and the sequence of these activities. This definition highlights three workflow building blocks: activity, roles and sequence.

Activities, roles and sequence are important building blocks of workflow when studying cooperative work in EDs. Activities include purposeful (i.e. goal oriented) actions, and operations [30]. An activity has a meaningful objective and produces a meaningful output that subsequently leads to other activities of the patient care episode. An output is a result of any progress towards the care of a patient such as a change in the health status of the patient, additions to the patient chart, any decision that will affect the course of the care.

Role theory defines role as “a behavioral repertoire characteristic of a person or a position” [31]. A role is a collection of duties and rights, generally embodied in a job type or position title, and often constrained by the license held by the role incumbent. Duties of roles are obligations that specify what activities a staff member...
may or cannot perform on behalf of patients. In the course of patient care, activities and roles emerge in a sequence. A sequence is an ordered list of elements [32]. In clinical settings, sequences (of activities and roles) are generative, dynamic processes that emerge in part as a function of known patterns and in part as a response to the patient's health state [33–36].

Unerli et al. [37] conducted a literature review to reveal various components of workflow and developed a workflow model. Their model includes "specific levels" which are actors, artifacts, actions (and their characteristics) and outcomes, and "pervasive levels" which are temporality, aggregation and context. The patient-oriented workflow methodology suggests that the components of workflow should be organized around patients. Therefore, examining these components for each patient care episode will allow us to examine cooperative work in clinical settings.

The patient-oriented workflow approach presented here is guided by the cooperative work framework [7]. According to Schmidt and Simonee [38], "Cooperative work is constituted by the interdependence of multiple actors who, in their individual activities, in changing the state of their individual field of work, also change the state of the field of work of others and who thus interact through changing the state of a common field of work." (p. 158) Schmidt and Simone [39] asserted that by involving multiple actors, cooperative work is inherently and inexorably distributed across many people, thus necessitating information exchange and coordination. The distribution of work in practice demands that some individuals have to be geared to each other. In the case of EDs, a patient constitutes the common field of work for clinical and non-clinical ED staff members. Multiple ED staff members work with the patient individually or together. An ED staff member's work with the patient affects other clinicians' work through the patient herself and through the patient related artifacts (e.g., patient chart or tracking board). The temporal order in which ED staff members contribute to the patient care can affect productivity and quality [40, 41]. Many principles of the cooperative work framework are readily applicable to study patient care in EDs.

The patient-oriented workflow methodology can provide a useful perspective to researchers and practitioners for examining individual clinicians’ work [43]. During a cooperative work, the involving parties often require great flexibility and choice in their procedures and coordination methods [44]. Such a tool can be used to gauge needed flexibility in clinical work systems.

Similar perspectives to patient-oriented workflow have been discussed. For instance, Strauss et al. introduced the concept of patient trajectories [45]. They focused on medical work that involves both multiple clinicians and patient in general. The patient-oriented workflow, in this specific study, particularly focuses on roles, activities and sequence more in detail within a more limited scope. In the following sections we describe a data collection tool to systematically observe the patient-oriented workflow in EDs. Care pathway, which is also similar idea to the patient-oriented workflow, "includes actions recommended by one or more protocols and guidelines, activity role constraints, and sequencing constraints; it has goals and it provides a record of care and information about the patient state and a 'variance record,' that is, a method for documenting and recording where deviations from the planned pathway have occurred" [46]. Patient-oriented workflow is useful to understand and explain these "variance records."

The potential contribution of the patient-oriented workflow methodology is providing an opportunity to examine the work from patient's perspective. In this study, we modeled patients' experiences in terms of sequences of activities by various clinicians and other staff members. Such an opportunity can lead to patient-centered care, which represents a philosophy of care delivery in which services are arranged around the needs of the patient [28].

2. Methods

2.1 Motivation

The patient-oriented workflow methodology was developed in response to the need in a larger project examining the impact of an information technology innovation on the care of patients in an ED. This project, referred to as the EDLinking project, is a health information exchange initiative that allows ED staff members access information about recent care experiences for patients whose care is paid for through state health programs (specifically Medicaid) [47, 48]. The central interest in the parent project was to determine whether the EDLinking project causes a delay in submitting the first prescriber (i.e. a physician, or a midlevel clinician who is either a physician assistant or a nurse practitioner) clinical order. Therefore, during evaluating the data collection tool, we intensively focused on the early stage of ED care (i.e. until first prescriber order).

In the following sub-sections we detail the design and evaluation of an observation tool, which was developed to capture patient-oriented workflow in EDs. The tool is designed to be stand-alone and appropriate for single observer studies.

2.2 Description of the Patient-centered workflow Data Collection Tool

We first created activity and role categories that reflected current practice in hospital based EDs and permitted efficient observation and recording by trained observers. We will discuss the activities first, then the roles. The activities included in the tool are registration, assessment, treatment, status update, and order. These activities are defined at a broad level and include observable behaviors and cognitive actions. In principle, activities can be broken down into arbitrarily fine-grained details [49]. In practice, larger chunks are usually more
meaningful [50]. Mutually exclusive and exhaustive categories facilitate coding and interpretation [51]. Therefore the activities codes were selected to be sufficiently broad to encompass recognizable behaviors and sufficiently well-bounded to allow for easy determination by an observer.

**Registration** includes actions related to the entrance of a patient to the ED service, such as interviewing patients, entering patient information to institutional information systems, and dealing with consent forms [52]. **Assessment** can be defined as the collection and documentation of primary and secondary information about a patient and the re-examining of this information in light of the outcomes of a care plan and intervention [53]. An assessment activity includes actions such as physical assessment, patient interview, chart review, and charting. A **status update** activity aims to update another ED staff member about the location or health status of a patient, commonly through interpersonal communication or broadcasting [54–56]. An **order** is a directive for a care process, including tests, medication, or procedures, that is formal, usually written or entered in to an electronic record [57]. A **treatment activity** includes therapeutic actions on behalf of the patient, such as medication administration, respiratory therapy, stitching, abscess incision and drainage, etc. [58].

We defined following roles as key to the care of patients in the ED: Emergency medical technician, administrative staff, middle-level clinician, ED technician, other technician, nurse, charge nurse, physician, triage nurse and other. Job titles (e.g. nurse) or the pre-defined more specific duty (e.g. triage nurse) of the ED staff members were used to represent roles. These titles and pre-defined duties of the ED staff members are discrete and each ED staff member carries only one role.

The data collection instrument was implemented on a tablet computer platform for facilitating and standardizing the capture of patient-oriented workflow using a Microsoft Access® database. The application includes a form that serves as the interface (Figure 1). Activities and roles are recorded with an automatic time stamp that supports later creation of sequences. The interface includes buttons for roles and activities, a text box to enter comments and a table that shows the recently entered data.
The activity and role lists were reviewed with an ED physician who has sixteen-year practice experience in EDs. The physician confirmed that the both activity and role lists are complete and not overlapping. Following the face validity, the data collection tool was assessed in terms of content validity, viability and inter-observer reliability. The development process is illustrated in Figure 2. The results of the evaluation are reported in Section 3.

2.3 Settings and Sample

We evaluated the patient-oriented workflow instrument in a field study at three Midwestern, urban hospital EDs. The three EDs are situated in three different hospitals; each in turn belongs to different health systems. The EDs are similar in structure (e.g. auxiliary care-fast track units, ICU rooms), and, they serve patients in the same metropolitan area. These three settings differ from each other in terms of size and technological resources used. Appendix 1 illustrates the layout of one of the study settings.

A total of 108 patient care episodes were observed through a non-probabilistic sampling method [59]. The main concern about the non-probabilistic sampling is the degree of representativeness of the sample with respect to the population. Guo and Hussey [60] suggested three strategies to ensure that the sample sufficiently represents different work situations. First, sample size should be as high as possible. For this study, 108 patient episodes were observed. The sample size is larger than several comparable studies available in literature [61]. Second strategy of Guo and Hussey is that sampling should be designed for diverse findings. Data to evaluate the tool was collected on various weekdays and at different times of day. Third strategy is that diagnostic tests should be performed to investigate departures of data from the statistical assumptions and take corrective measures if detrimental problems are present. The sample of this study was evaluated to assess the representativeness of the sample by comparing the observation data with the data retrieved from the institutional computer system in terms of duration (Mann-Whitney U test, p > 0.05).

The strategies we employed ensured that our sample is sufficiently representative and establish a level of external validity.

2.4 Observation Procedure

An observation procedure was developed to systematically apply the patient-oriented workflow tool to document the care of a single patient by a single observer. The observations were conducted between June 2009 and August 2010. A total of 120 hours of observations were conducted in about thirty-four-hour sessions.

In this study, we utilized patient-oriented workflow methodology to characterize the clinical care processes delivered to a single patient in a single encounter. Because the goal of this workflow model is to document the engagement of various practitioners rather than to document specific clinical care interventions, a broad perspective on the care process is required, and direct, close observation of clinician-patient interaction is not required.

Different observation strategies are employed at a different stage of the patient care process. The first stage starts with arrival of patient. Patient shadowing is employed as the observation strategy at this stage. Typically, the second stage starts when the patient is taken to a patient room and includes clinic observation; to preserve patient privacy and to minimize care disruption, the observer stays at a central place so that the patient room, the chart rack and status board are in sight. Typically, the third which is the last stage starts after a prescriber assesses the patient. Clinician shadowing is the observation strategy at this stage. Observation of this specific patient is concluded when an order is given by the prescriber.

Each observational record contains three data elements: time, role, and activity.

3. Results

We proposed a data collection tool consistent with the patient-oriented workflow methodology. The tool was evaluated in a field study in terms of content validity, viability and inter-observer reliability.

3.1 Content Validity

Content validity "depends on the extent to which an empirical measurement reflects a specific domain of content" [62]. The content validity of the activity and role coding schemes were assessed by comparing the coding schemes of activities and roles with similar lists available in the literature.

The list developed by Hollingsworth et al. [63] was used as the reference to define the content of patient care activities in EDs. Their list includes twenty-seven activities. Five raters, one industrial engineer, two nurses, and two ED physicians, mapped activities of Hollingsworth's activity list onto the activity scheme described in section 2.2. The content validity raters were asked the following question: "If an activity can be coded with (activity A) by using Hollingsworth et al's activity list, can the same activity be coded with (activity B) by using the recently developed activity list?" The raters were provided an empty form that includes Hollingsworth et al's and our activity list (as the recently developed list) to facilitate their input. The communication with the raters was accomplished through e-mails.

Table 1 shows the summary of how the five raters matched Hollingsworth et al's list onto the activity list described in

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At least any four of the five raters agreed that eighteen of the Hollingsworth et al.'s activities are mapped onto one or more activities of our coding scheme. The following nine (the grayed out activities in Table 1) activities available in Hollingsworth's list were not covered by the list developed in this paper: transporting patients, teaching residents or students, research, signing up for patients, walking, preparing medications, processing lab specimens, cleaning or stocking rooms and personal time.

Three main factors are accountable for the exclusion of the nine grayed out activities listed above. The first factor is the setting characteristics. The settings are non-academic. Therefore, there is no academic teaching or research functions as a part of the practice. Second, the nature of the work in EDs does not allow us to observe some activities such as “preparing medications” within our scope (i.e. time until the first prescriber order). Third, the patient-oriented workflow approach uses goal oriented versus behavior oriented activity definition. For example, “walking” or “transporting” patients is not included as an activity in the coding scheme because these behaviors themselves do not have an inherent meaningful goal; however, activities listed in our data collection tool may cover these behaviors.

For the content validity of the roles, a study that focuses on communication patterns in EDs was used to extract an extensive list of roles that involve ED patient care [64]; the purpose is to ensure the completeness of the coding scheme. We used this paper as the reference because, to our knowledge, this study provides the most comprehensive list of roles. The assessment showed that our role list includes eight of eleven essential roles related to patient care in EDs. Table 2 shows the match between Fairbank et al.’s list [64] and our activity list. The first column shows the roles that were retrieved from Fairbank et al.’s study. The second column shows the corresponding roles in the role scheme that was included in the tool. As shown in the table, the developed coding scheme for roles does not include the following roles: Resident, other physicians and pharmacist. The exclusion is because of the scope of the project, which is until the first prescriber order.

Content validity showed that the developed coding schemes (for activities and roles) of the tool sufficiently reflect the existing roles and activities in three EDs.

### 3.2 Viability

Viability refers to the ability to collect data on patient care episodes by using the data collection tool in a consistent way with the aim of the developing of the tool. The tool was developed to systematically characterize patient care episodes until first pre-
scriber order in EDs as workflows. This aim was accomplished by creating a sequence of activity-role pair for actual patient care episodes. After finalizing the tool, it was used in three EDs, and the observers were able to capture a total of 108 patient care episodes. Four example workflows from three EDs are given in Figure 3.

In Figure 3, the most left workflow shows an actual patient care episode (Episode A) observed in ED-1. Each box includes activity, role and time information. The episode started with a triage nurse assessment at 12:04, followed by two registration activities by administrative staff at 12:08 and 12:16, one nurse assessment at 13:32 and a mid-level clinician assessment at 13:34. The last activity of the episode was

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<td>Physician</td>
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**Figure 3** Four examples of patient-oriented workflows captured by using the tool. Each box includes activity, and roles and occurrence time in parenthesis. Each workflow shows an actual patient care episode, each of which was observed on different days.
observation study depends on the coding schemes and observer training.

A total of 37 workflows were observed by two observers simultaneously in seven observation sessions. The first author was always one of the observers and in 22 observations the second observer was a nurse, while in 15 observations the second observer was an industrial engineer. Second observers (two nurses and two industrial engineers) were trained before the observation sessions. To optimize reliability and minimize the potential for observation error a training manual was prepared. The training manual explained the coding schemes (i.e. activity and role categories) in detail. Observers also familiarized themselves with the ED environments, the tablet PC and the Microsoft Access® application which accommodates the tool before the observations.

Inter-observer reliability was assessed in two out of three study settings (13 and 24 patient care episodes observed in ED-1 and ED-2 respectively). The data collected by two observers were compared in terms of activities, roles, and sequence. We used GSEQ software, which is an application designed to analyze sequence data to calculate kappa values [66]. Our results revealed a kappa value of 0.79. In general, a Cohen’s kappa value bigger than 0.7 implies a significant level of reliability [67]. Table 3 shows the reliability results taken at the different observation sessions.

Table 3 shows that the Cohen’s kappa between observation sessions highly fluctuates. The reason may be individual characteristics of observers and small sample sizes. It was impractical to hire a fewer number of second observers. There are advantages and disadvantages of having many observers with less amount of observation time for each observer. The main advantage is that observer effect was minimized. The disadvantages are training time was longer. In one of the observation sessions, the kappa value was low (0.52) due to observer related reasons.

The evaluation of the observation tool described here provided support for inter-observer reliability. The summary of the evaluation of the observation tool is given in Table 4.

4. Discussion

The purpose of this paper was to introduce the patient-oriented workflow methodology, designed to allow researchers and practitioners to characterize patient care by using the concept of workflow, and provide evidence of the validity, viability and reliability of a data collection tool guided by the methodology. This new approach has a broader perspective than the commonly utilized clinician-oriented workflow approaches. We proposed to organize the study of workflow not from the perspective of the worker, but oriented around the patient, the focus of work. By using the patient-oriented workflow methodology, we were able to capture the sequence of activity role pairs as a result of cooperative work. Patient-oriented workflow approach goes beyond the scope of individual clinicians’ jobs and focuses on the common workspace (i.e. patient) on which multiple clinicians work together. Because the unit

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<td>Viability</td>
<td>Using the tool at three EDs.</td>
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<td>Content Validity</td>
<td>Comparing the activities and roles with two previous studies (i.e. [63, 64]).</td>
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<td>Interobserver Reliability</td>
<td>Comparing data collected by two observers on the same patient care episodes.</td>
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*For the given scope (until the first prescriber order)
of analysis is single patient episodes, the variability across the patient care episodes can be examined.

We also described a data collection tool based on the patient-oriented workflow methodology and tested the tool through an observational field study that includes 108 patient care episodes in three EDs. The wide spectrum of these episodes provides evidence of the tool’s content validity, viability and inter-observer reliability. We provided a systematic way to assess validity and reliability of an observation tool. To our best knowledge, no previous study compared an observation tool with a previously developed list to establish content validity. Moreover, inter-observer reliability assessment of the previously developed workflow observation tools for clinical settings did not produce a kappa value, which provides objectivity. Systematic evaluation increases the credibility of the data collection tool and assists other researchers and practitioners deciding on whether they can use the tool for their study. We tested the tool in ED settings. However, the coding schemes on roles and activities are theory-based, they can be tailored in other settings. Therefore, the tool can serve as a starting point to use patient-oriented workflow methodology in other care delivery settings.

Figure 3 represents four of the patient care episodes we captured. These four episodes are different from each other in terms of involved activity-role pairs and their sequences and represent a portion of the variability in ED work. Variability in ED work is accomplished by cooperative work among ED staff members [24, 68]. Understanding cooperative work that is performed in care delivery settings is then essential to improve quality, efficiency and safety. Moreover, Work interventions such as technology implementation have impacts on cooperative work groups [12, 69, 70]. The patient-oriented workflow methodology allows for examining cooperative work in care delivery settings.

This paper contributes to workflow research by introducing the patient-oriented workflow methodology and describing an observation tool to systematically capture workflow in care delivery settings. The tool allows researchers to examine actual patient care episodes in care delivery settings. Patient care services provided to a single patient is self-contained, feasible to study, has clearly defined boundaries, and provides significant information to understand complex health care work. Understanding patient care episodes in situ provides a better understanding of cooperative work and informs work interventions that aim to improve the efficiency of patient care delivery and affect work of multiple roles.

Health information technologies such as electronic medical records, nursing communication tools and personal health records are designed to connect heavily distributed health care delivery systems. The design, implementation and evaluation of these technologies require rigorous and systematic workflow methodologies. As identified by Zheng et al. [71] there is a discrepancy across the findings of health IT studies in terms of their impact on workflow. As they speculated the discordance may be due in part to the oversimplified workflow modeling practices. The patient-oriented workflow methodology and the tool we described here can assist researchers with collecting data that depicts the salient aspects of true work such as roles, activities and sequence in care delivery settings.

The study includes a number of limitations. By choice we decided to limit the scope with the early stage of patient care (i.e. until the first prescriber order). This choice allowed us to focus on a specific part of care intensively. We tested the tool in three settings. The settings are selected because of their participation in the ED-Linking project. However, these EDs share characteristics with a range of urban, non-academic hospital EDs in the US including bed capacity, used technology and type of services provided. The tool can be tailored by adding more activities and roles for other clinical settings (e.g. academic EDs). In this specific study, time was conceptualized as a point rather than an interval. Therefore, the degree of overlap of the activities in time was not represented. The content validity assessment of the data collection tool involves subjectivity to some extent.

Appendix 2 includes a procedural summary that we propose for studying patient-oriented workflow in future studies.

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