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Synchronized Time-Motion Study in the Emergency Department Using a Handheld Computer Application

Phillip V. Asaro

Division of Emergency Medicine, Washington University School of Medicine, St. Louis, Missouri, USA

Abstract

Emergency departments present a challenging environment for workflow evaluation and measurement of the effect of information system interventions. This paper describes a time-motion data collection tool built as a handheld computer application. The tool allows mobility of the observer and the intuitive interface supports rapid selection of tasks and frequent changes in tasks. It also allows documentation of overlapping tasks, a common occurrence in the emergency department. Synchronized data collection across the different providers of care in the emergency department is demonstrated, resulting in a data set from which task/event sequences can be built, documenting the ED care of individual patients. This technique should provide a very useful tool in measuring the effect of process changes in this difficult-to-assess environment, particularly changes in the information system.

Keywords:

Time and Motion Studies, Handheld Computers, Process Measures, Emergency Medicine

Introduction

Emergency Departments (EDs) across the country are struggling to provide timely and high quality care under an ever-increasing burden of higher volume and sicker patients, leading to what has become a nationally recognized crisis in emergency care, particularly in urban academic EDs.[1] Time-motion studies have long been used to provide insights into work flow issues in health care.[2] They have been used in several ways in the ED, including study of task interruptions.[3,4] Time-motion studies are often performed using paper, pencil and stop watches, but this approach has its limitations. Using stop watches to record durations does help to answer questions about what caregivers spend their time doing, but cannot provide information about the interactions of activities across care providers. Capturing starting and ending times of activities along with a description of the activity is difficult, particularly in the emergency department, due to frequently changing and sometimes overlapping tasks. For example a physician may view laboratory results on a computer during the course of a telephone discussion with a consulting physician. Whether this situation represents overlapping activities depends, in part, upon the degree of granularity with which the study is done. For the purpose of studying the effects of information-system implementations on user workflow, a high degree of granularity is desirable. In such settings, handheld computer applications have been found useful in capturing activities in a sufficiently high resolution and granularity. [5] Typical time-motion studies provide information about what subjects do with their time. Comparisons can be made across different settings or to determine effects of workflow interventions in the healthcare workplace, such as the effect of physician order entry on clinician time. [6]

In addition to the activities of emergency department physicians and nurses, the activities of other care providers are also of interest, including: consulting physicians, ED technicians, radiology technicians, phlebotomists, ECG technicians, respiratory therapists and housekeeping personnel. Furthermore, the interactions and dependencies between the activities of care providers are of significant interest in the emergency department. Capture of information regarding these interactions and dependencies might be useful in efforts to improve efficiency. This paper describes the use of a tool that supports synchronized time-motion data collection across multiple providers of care using a handheld computer application.

Methods

Data Collection Tool

The tool is designed to be operated in one of three modes, to capture observations from any one of three perspectives – the ED physician, the ED nurse, and the patient/room. The patient/room observer perspective allows the capture of activities of care not provided directly by an ED physician or nurse such as being brought to the room or having blood drawn by an ED technician. It also allows capture of times not related to patient care such as arrival of housekeeping personnel to clean rooms between patients. Observed activities can be viewed as tasks or as events depending upon the event/task and the context of analysis. Particularly with regard to the observations made from the patient/room perspective, much of the observed activity may be regarded as events in the patient's care rather than tasks performed by a provider. Hence both event and task, and occasionally the more general term activity, are used in this paper depending upon the analytic context.

The application was developed in Satellite Forms (Pumatech, Inc., San Jose, CA, USA) for the Palm OS (PalmSource, Inc., Sunnyvale, CA, USA). The tool is designed with buttons and pick lists allowing categorization of activities in an easy and intuitive manner (see Figure 1). The tool has separate forms for each perspective (physician, nurse, and patient/room). On each form, there are up to eight buttons for high-level categorization of possible events. On the physician form, for example, button categories include "with patient", "with nurse", "with doctor", "information system", "paper chart", "in transit", "phone", and "other". For each of these categories, there are more specific subcategories with descriptions displayed in a pick-list filtered by the category buttons. Timing of the activity begins when the button is pressed, allowing some deliberation before picking the subcategory while the activity continues. This is an important feature, allowing separation of task timing from task identification as Starren et al [5] and Overhage et al [6] also found. The exact nature of the task is often not readily apparent as the task begins. Figure 1 shows the tool after timing of physician activity in a patient room. The timing began 16 seconds ago and the observer is about to select from the pick list in the center of the screen to further define the activity. The task prior to this is shown at the bottom of the screen and was a transit to the patient room.

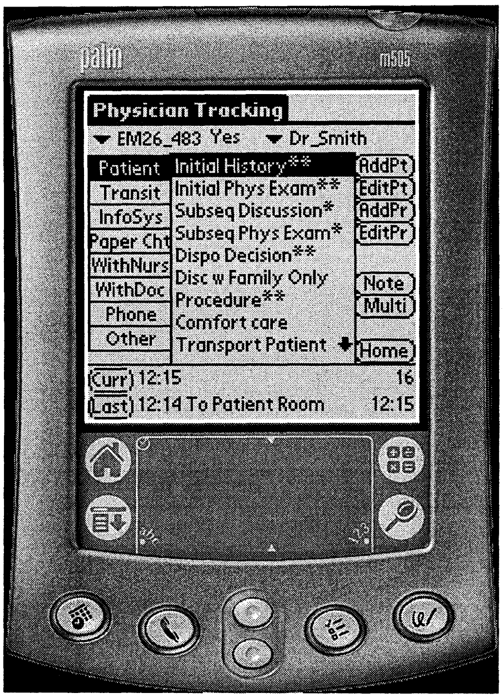

Figure 1 -

To capture timing of overlapping activities, the tool allows simultaneous timing of two activities. The user taps a button labeled "multi" before selecting the second activity. Both activities are then timed in this multitask mode until either activity is ended by tapping one of two "end" buttons that appear at the bottom of the screen during timing of overlapping tasks. For each recorded activity, the device ID and a sequentially generated event ID are recorded, together creating a unique key for that activity in that session. Also recorded for each activity are start time, stop time, duration, event-type code, patient ID, and provider ID. For activities involving multitask mode, a link to the overlapping activity is recorded.

Study Environment

Observation occurred during 9 sessions in the 62 bed emergency department of a large urban academic medical center. Each session consisted of approximately 4 hours of observation in a designated area of the ED defined primarily by physician-team responsibility. Nursing responsibilities did not always coincide exactly to the physician team responsibilities. In these cases, observations of some of the nursing activities were on patients cared for by physicians outside of the study at that time. Observation sessions were conducted in the Trauma/Critical Care Unit (1 attending, 3 residents, 3 nurses, 1 session), EM1 (1 attending, 2 residents, 2 nurses, 2 sessions), EM2 (1 attending, 1 resident, 2 nurses, 1 session), EM2S (1 attending, no residents, 2 nurses, 2 sessions), Urgent Care (2 or 3 physician assistants or nurse practitioners, 2 nurses, 2 sessions), and 1 session in EM1 during a resident retreat (2 attendings, no residents, 3 nurses). The session in EM1 without residents is representative of the staffing in this area during the weekly emergency medicine conference mornings. Staffing during the remaining sessions was typical for those areas. No observations were conducted in the ED Observation Unit as workflow in this area is quite different and less standardized than in the rest of the ED.

Data Collection

Data collection was performed by students who were provided incentive to assist in the project by $25 gift cards for local specialty stores. Medical students performed most of the physician and nurse tracking. Much of the patient/room tracking was performed by undergraduate students who were enrolled in a medical research course. Patient/room observers monitored rooms from the hallways and were responsible for monitoring between 3 and 5 rooms at one time. They were asked to prioritize the capture of non-physician and non-nurse related events when activity occurred in more than one room at once.

Observers were trained during an approximately 2-hour session. The use of the tool was demonstrated in a classroom setting and the structure of the task categorization scheme was reviewed. They were also shown the various paper chart forms as well as the various information system applications they would need to recognize.

They practiced on the handhelds in the classroom for a short time. Then they were assigned to track providers in the emergency department for about 45 minutes during which time any questions they had could be answered while the author circulated amongst them. After this practice observation session, they returned to the classroom where any additional questions were answered.

Data Analysis

Table 1

Following each observation session, the data were collected onto one handheld computer using an infrared beaming function incorporated into the tool. Then the entire data set was uploaded to a desktop computer via a cradle connection and imported into

Microsoft Access. A session ID was added and the data from all sessions were combined. Each of the 214 event types (items that could be chosen by the observers from the lists on the tracking screens) was categorized into one of three major categories – direct patient care (tasks completed in contact with patients and family members), indirect patient care (including documentation, care-planning, order processing, etc.), and other (personal time, waiting, administrative, etc.). They were also categorized according to the tracking mode (physician, nurse, or patient/ room) and the task category selected by the user by tapping the buttons on the screen. Finally, an additional categorization was applied yielding the subcategories as seen in Table 1. Analysis was then done using Microsoft Access and Excel, including liberal use of pivot tables.

The combined event/task list was subsequently sorted on room and date/time to create a longitudinal record of each patient's care in the ED during the observation sessions. While some patients had already been under care for some time before a session began and others arrived just prior to the end of a session, there were a number of patients for whom a meaningful longitudinal record was created. Through manual inspection of this record, individual events/tasks were labeled as milestones in the patient's care, creating a summarized timeline of the care of that patient. Additionally, by sorting on patient room, a record of room-specific events and intervals between patients was created. From the labels that were attached, patient care process intervals were then calculated. The calculated intervals were: arrival in room to initial nurse assessment, arrival to first physician (or NP/ PA) evaluation, initial physician orders to initial order fulfillment, arrival to disposition decision, initial physician evaluation to disposition decision, arrival to patient disposition (leaving ED for discharge or inpatient room), patient disposition to room being cleaned by nurse, patient disposition to arrival of housekeeping, arrival of housekeeping to arrival of next patient, and disposition of patient to arrival of next patient. Not all intervals were clear from the data collected and some events did not apply to some patients. For example, in a few patients, the time of disposition-decision was not clear from the data collected. Urgent care rooms often do not require housekeeping services between patients. Sometimes nurses must clean equipment or items contaminated by bodily fluids, since there is a limit to what housekeeping will do in such circumstances. Other times nurses do not become involved in the cleaning process

Table 2.

		Physician NP/PA	Nurse
All Tasks	Seconds	339708	271825
	Task Count	4349	3887
Overlapping	Seconds	25106	12571
	Instances	357	231
	Task Count	714	462
% Overlap	Time	7.4%	4.6%
	Task Count	16.4%	11.9%

Results

Over the 9 observation sessions the following providers were tracked:

- 17 nurses in 20 nurse sessions (3 nurses twice)
- 7 attendings in 8 sessions (1 attending twice)
- 11residents in 8 full resident slots (shift changes)
- 5 NP/PA's in 4 ½ sessions (1 for a partial session)

Table 1 shows the breakdown of total task duration by category of task and provider group type in terms of percentage of total for provider group.

Overlapping Tasks

The task overlap for physician and nurse provider groups is shown in Table 2. For the physician/NP/PA group, 16.4% of tasks involved an overlap with another task. This overlap accounted for 7.4% of total task time. For nurses, 11.9% of tasks involved overlap accounting for 4.6% of total task time. The more common overlapping tasks for physicians were as follows (with total overlap time in seconds followed by number of occurrences in parentheses): combining history taking or discussion with physical examination (4396/27), documenting on paper while in direct patient care (2189/14), using the information system while working with the paper chart – documenting results or order writing (3463/49), using the information system while on the phone – care-planning with other physicians and probably passing some time on hold (1241/21), using the information system while care-planning with other physicians directly in the ED (3455/40), working with the information system while care-planning with or giving orders to a nurse (982/26), writing orders in the paper chart while care-planning with another physician (1212/27), and care-planning with a nurse while documenting in the paper chart – including writing orders (994/22).

Event Sequencing

Using the labeled list of events/tasks sorted by room and date/ time, 92 patients were found that had measurable intervals within the patient visit and 26 instances in which the interval between two patients was observed. Table 3 shows the intervals.

Discussion

The time spent by providers performing various tasks as observed in this study, using our handheld data collection tool, is generally similar to previously reported emergency department time-motion data.[3,4] We did observe differences in activity breakdown across different areas of the ED and depending upon whether attending physicians are working alone or with residents. The significance of the findings will depend upon the purpose of the analysis. The purpose of the analysis will in fact determine the unit of analysis. For example, analysis might be at the overall session level if one is evaluating performance of the ED on different days of the week. For evaluation of the variance between individual providers or groups of providers, the analysis might be at the provider-session level.

Table 1

Category	Sub-Category	Nurse	Attending	NP/PA	Resident	Non-Nurse Totals	All-Provider Totals
Direct	Nursing Assessment	5.6%	0.0%	0.0%	0.0%	0.0%	2.5%
	CarePlanning At Bedside	0.0%	0.1%	0.1%	0.3%	0.2%	0.1%
	History & Physical	0.0%	19.6%	20.3%	13.6%	16.9%	9.3%
	Other/Unknown at bedside	11.0%	0.0%	0.0%	0.0%	0.0%	4.9%
	Procedure	20.7%	2.5%	7.5%	6.2%	5.3%	12.2%
	Other Discussion - Pt & Family	2.8%	5.9%	3.5%	5.6%	5.3%	4.2%
Direct Total		40.2%	28.1%	31.4%	25.8%	27.6%	33.2%
Indirect	ADGO (Lab/X-ray Order Result)	2.7%	3.2%	0.8%	2.0%	2.2%	2.4%
	HMED (ED tracking system)	6.1%	9.3%	16.1%	7.5%	9.7%	8.1%
	ClinDesk (Data Repository)	0.0%	2.4%	0.0%	1.4%	1.5%	0.8%
	Login to computer	0.3%	1.1%	0.5%	1.1%	1.0%	0.6%
	Care Planning With Other Providers	9.9%	18.6%	7.2%	19.8%	17.0%	13.8%
	Direct Care Related (e.g. transit)	11.9%	4.7%	4.3%	5.7%	5.2%	8.2%
	Paper Documentation	16.3%	12.8%	17.6%	8.8%	11.8%	13.8%
	Knowledge Acquisition (e.g. ref. book)	0.0%	0.3%	1.6%	0.9%	0.9%	0.5%
	Other/Unknown	5.3%	2.3%	2.4%	3.5%	2.9%	4.0%
	Prescribing Care (paper orders/scripts)	0.0%	5.4%	1.4%	3.8%	3.9%	2.1%
	Procedures (e.g. lab procedures)	0.0%	0.0%	0.3%	0.1%	0.1%	0.0%
	Family Discussion by phone	0.0%	0.2%	0.2%	0.0%	0.1%	0.1%
	Patient Info Review, Other (paper)	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%
	Results Review (paper, X-ray)	0.0%	2.6%	0.6%	2.6%	2.2%	1.2%
	Searching (for people, supplies, etc.)	1.3%	1.2%	2.4%	2.1%	1.9%	1.6%
	Teaching Students	0.0%	1.4%	0.0%	0.7%	0.8%	0.5%
Indirect Total		53.6%	65.2%	54.8%	60.0%	60.8%	57.6%
Other	Cleaning	1.2%	0.0%	0.1%	0.0%	0.0%	0.5%
	Other/Unknown	0.9%	0.3%	0.3%	0.3%	0.3%	0.6%
	Personal/Waiting	4.2%	6.1%	12.8%	13.7%	11.0%	8.0%
Other Total		6.2%	6.6%	13.8%	14.2%	11.6%	9.2%
Grand Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

One potential use for accurately timed direct observations is correlation between the times of observed activities and the corresponding times as documented in the patient record or information system. We implemented physician order entry along with electronic nursing documentation in our ED after the completion of the data collection described in this paper. We expect to use the data now collected by the information system in performance improvement projects directed at patient care processes. We know that the order timestamps are accurate since ordering is performed in the system. However, time of documentation of order fulfillment (obtaining blood samples and medication administration) is not tied directly to the performance of those tasks. We would like to have a measure of the variance between the performance of such tasks and the documentation thereof. Direct observation would be the best way to capture the information and the accurate timing that is a basic function of the handheld computer application is critical in data collection for this purpose.

Table 3

	EM1	EM2	UC
Arrival to Nurse Assess	7 (1-21)	9 (1-25)	24 (1-56)
Arrival to First Phys Eval	14 (1-40)	14 (0-83)	28 (0-118)
First Orders to Fulfillment	13 (2-47)	12 (2-30)	
Arrival to Dispo Decision	66 (38-114)	99 (59-141)	69 (20-151)
Arrival to Dispo	114 (73-142)	104 (66-143)	88 (41-152)
Dispo Decision to Dispo	62 (8-142)	42 (7-121)	21 (1-72)
First Phys Eval to Dispo	54 (17-111)	82 (18-132)	40 (7-146)
Dispo to Nurse Clean		8 (1-31)	8 (1-12)
Dispo to House-keeping	13 (13-13)	12 (1-34)	14 (11-16)
House-Keeping to Arrival	17 (17-17)	27 (4-113)	7 (7-7)
Dispo to Arrival	23 (8-58)	32 (8-118)	37 (2-103)

Synchronization of activity timing across multiple observers supports the construction of interval data through analysis of event sequences, but care must be taken to identify sampling biases. For example, the lengths of stay (arrival to disposition intervals) we measured are clearly not representative of our ED and should in no way be viewed as a measure of length of stay. Wait times for inpatient beds are frequently many hours and turn around times for many radiology tests are much longer than these lengths of stay would suggest. Since we were only observing for four hour sessions, we were much more likely to capture intervals during shorter ED stays. The patients that remained in ED beds for the entire session awaiting an inpatient bed or results of evaluations are not included in that data.

Nonetheless, interval data may be of use in other ways. For example, room turn-around time is a concern. Since we virtually always have patients in the waiting room, we are always in need of bed space. We know that beds sometimes remain empty for extended periods between patients. If it is thought that the problem is getting the rooms cleaned by housekeeping, this data might suggest other factors are involved. The intervals between the arrival of housekeeping and arrival of the next patient are longer than the intervals from disposition to arrival of housekeeping in this data set.

Our initial data collection reveals significant overlap of tasks. Many of the overlapping tasks observed relate to tasks that are impacted by changes in the ED information system that have been implemented since these data were collected. We plan to perform another cycle of time-motion data collection for comparison to this data set for the purpose of evaluating the effects of the information system changes on provider workflow. We expect to see differences in time spent on a number of tasks including paper documentation and use of the computer systems. The capability of our handheld application for measuring overlapping tasks is viewed as critical for this purpose. In the future, we will be considering implementation of electronic physician documentation. We have significant concerns regarding an increase in physician time required for documentation using the proposed system. Time-motion study may also provide a measure of this effect in a pilot trial before committing the entire ED to such a change.

Conclusion

The handheld computer application described enables collection of a highly useful data set in the hectic environment of a hospital emergency department. The application readily supports the collection of time synchronized data across multiple providers or perspectives. Capture of other "events" in care provides opportunity to obtain measures of care processes not possible with standard time-motion studies. Allowing timing of overlapping tasks is also apparently important, particularly in the evaluation of how information system changes affect provider workflow, in that providers often do documentation and use the information system in conjunction with other tasks.

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Address for correspondence

Phillip Asaro, MD, Campus Box 8072, 660 S. Euclid Ave., Washington University School of Medicine, St. Louis, MO 63110