MEDINFO 2013
C.U. Lehmann et al. (Eds.)

doi:10.3233/978-1-61499-289-9-303

Whiteboard Icons to Support the Blood-Test Process in an Emergency Department: An Observational Study of Temporal Patterns

Arnvør á Torkilsheyggi[a], Morten Hertzum[a], Gustav From[b]

[a] *Computer Science and Informatics, Roskilde University, Roskilde, Denmark*
[b] *Emergency Department, Slagelse Hospital, Slagelse, Denmark*

Abstract

The competent treatment of emergency department (ED) patients requires an effective and efficient process for handling laboratory tests such as blood tests. This study investigates how ED clinicians go about the process, from ordering blood tests to acknowledging their results and, specifically, assesses the use of whiteboard icons to support this process. On the basis of observation and interviews we find that the blood-test process is intertwined with multiple other temporal patterns in ED work. The whiteboard icons, which indicate four temporally distinct steps in the blood-test process, support the nurses in maintaining the flow of patients through the ED and the physicians in assessing test results at timeouts. The main results of this study are, however, that the blood-test process is temporally and collaboratively complex, that the whiteboard icons pass by most of this complexity, that attending to the icons is yet another temporally sensitive activity to remember, and that whereas the assessment of test results is integral to patient treatment, the acknowledgement of having seen the results is a formal add-on, the responsibility for which is sometimes unclear.

Keywords:

Emergency department, Laboratory tests, Temporal patterns.

Introduction

Laboratory tests such as blood tests are an important element of the diagnostic work in emergency departments (EDs). The competent treatment of ED patients therefore requires an effective and efficient process for ordering blood tests, knowing that the blood samples have been taken, being alerted to the availability of test results, and acknowledging having seen the test results. While this blood-test process constitutes a simple, four-step temporal pattern, it is intertwined with multiple other temporal patterns in ED work [1]. Some of these patterns relate to the around-the-clock nature of ED work, which implies that clinicians are replaced at the end of each shift; others relate to the individual test result, which may require immediate action or be unalarming; still others relate to how long different groups of clinicians have worked in the ED, which implies differences in experience and seniority; and still others again relate to additional aspects of ED work. In this study we analyze how these intertwined temporal patterns make the blood-test process inherently collaborative and discuss implications of this analysis for information systems, specifically whiteboards, intended to support the blood-test process.

We conduct our study at the ED of a medium-sized hospital in Region Zealand, one of five healthcare regions in Denmark. The physicians at this hospital have long been able to view blood-test results electronically and, since October 2011, the acknowledgement of having seen the result of a blood test has also been given electronically. The latest addition to the support of the blood-test process is the introduction, in April 2012, of icons indicating the four steps of the blood-test process (ordered, taken, results available, and acknowledged) on the electronic whiteboard. This whiteboard provides selected information about each patient, such as triage level, chief complaint, responsible nurse, responsible physician, and the status of blood tests. While most of the whiteboard information is updated manually, the status of blood tests is updated automatically. The whiteboard is a central artifact in the coordination of ED work and in maintaining an overview of patients' progress toward discharge [2]. Our study of the blood-test process is based on observations and interviews at the ED. To contextualize the data from the ED we supplement them with similar observations and interviews at the Medical Department of the same hospital.

The blood-test icons on the whiteboard alert the clinicians of the availability of new test results by means of a colour-coding that also indicates when the result of a test is abnormal. Previous work has shown that being alerted when new test results are available is a highly valued feature of information systems in an ED [3]. It is, however, well-known that alerts from information systems are not enough to ensure consistent follow-up on test results. Previous studies show that in EDs between 1% and 75% of test results lack follow-up with impacts ranging from no negative effect to death [4]. Sittig and Singh [5] make eight recommendations for reducing failures in test result follow-up, including increased clarity about who is responsible for following up and fully realizing that acknowledging having seen a test result does not guarantee an appropriate follow-up action. In a similar vein, Singh et al. [6] propose ten strategies for better management of abnormal test results, including that alerts must not be over-used because this creates alert fatigue. Careful consideration of when to use alerts becomes even more important in light of the finding that ED clinicians differ considerably in the number of tests they order, suggesting that much diagnostic testing is unnecessary and warrants neither alerts nor the attention of clinicians [7].

In the following section we describe our methods of data collection. We then analyze the temporal patterns in the work with blood tests at the ED and the collaborative nature of this work. Finally, we discuss implications of our analysis for how to support a safe, effective, and efficient blood-test process.

Method

This study was approved by the management of the two departments at which observations and interviews were conducted. The observed and interviewed clinicians were individually informed about the study and orally consented to take part.

Departments and participants

The studied ED consists of a total of 21 patient rooms divided among a fast-track area for walk-in patients, two acute areas, and a long-term area. The ED employs a total of 120 nurses and 13 full-time physicians. The work in the ED is conducted in cooperation with the other departments in the hospital. Specifically, the Medical Department is responsible for the clinical part of the treatment of medical patients in the ED, while the ED is responsible for the organization of the work.

The observations at the ED consisted of shadowing 3 junior physicians (i.e., residents), 3 physicians from the Medical Department as they were working their shift in the ED, and 2 nurses. In addition, informal interviews were conducted with 2 nurses, 2 laboratory technicians, a coordinating nurse, a triage nurse, and a secretary. Supplementary observations were made at the Medical Department and involved shadowing 3 teams of one senior physician (i.e., attending physician) and one nurse.

Procedure

The observations were made by following (shadowing) selected clinicians for a couple of hours at a time as they went about their work. This procedure allowed for the observer to get an overall understanding of the clinician's evolving tasks and the multiple temporal patterns in ED work. In particular, it allowed for observation of work with blood tests and the way this work affected and was affected by the different patterns in the work at the ED. The shadowed clinicians also consented to answering questions about the work they were performing, thereby explaining individual activities, clarifying relations among activities, and offering informed opinions. These questions as well as the informal interviews served to elaborate upon the observations. The work in the ED was observed for 19 hours.

Whereas the observations in the ED were not tied to specific clinical activities, the observations in the Medical Department were conducted during the ward rounds. On three different days, the observer followed a team of one senior physician and one nurse, as they prepared for, performed, and followed up on the ward round. These observations amounted to five hours.

All observations and interviews were conducted by the first author and documented in real time in detailed notes.

Data analysis

The observation and interview notes were subsequently elaborated and written into comprehensive summaries. The data were initially analyzed by thoroughly reading through the summaries and comparing different observations. This analysis led to the identification of a heterogeneous set of issues important to the blood-test process. These issues were then analyzed and structured using Zerubavel's [1] concept of temporal patterns as a theoretical framework.

Results

The observations focused on the work with blood tests, and the way the icons on the whiteboard supported this work. In the following section we first relate the blood-test process to the overall coordination and synchronization of ED work, then analyze the four steps of the blood-test process in turn.

Coordination and synchronization of ED work

The complexity of the blood-test process becomes apparent when it is seen together with the temporal patterns involved in the coordination of a patient's trajectory through the ED. This trajectory involves multiple clinicians who perform multidisciplinary work, with physicians, nurses, and secretaries responsible for different parts of the patient trajectory. This requires continual synchronization and coordination among the clinicians in order for them to maintain a shared understanding of who is responsible for which patients and to know when to perform the tasks for which they are responsible.

In our observations we have focused on four initial, sequential steps in the patient's trajectory through the ED: (1) Triage: The triage nurse evaluates how acutely the patient needs to be seen and which resources should be called upon. (2) Admission: The admitting nurse admits the patient. (3) Initial examination: A junior physician performs an initial examination of the patient and documents it by writing a patient record. (4) Examination: A senior physician takes over and performs the full examination, which concludes in a plan for the further treatment of the patient. This plan includes a decision about whether the patient should be transferred to another department or discharged. It may, however, take some time before the patient actually leaves the ED.

The synchronization of these steps is supported by the whiteboard. The triage nurse's evaluation results in a triage level ranging from 1 to 5 (1 being the highest level of acuteness). The triage nurse adds this information to the whiteboard to make it readily available to all physicians and nurses. The triage nurse also adds a label to the whiteboard showing which specialty should treat the patient (e.g., whether the patient is a medical or surgical patient). When the triage nurse has completed the triage, the admitting nurse takes over. When she has finished the admission, she changes the status in a column on the whiteboard, so the junior physician can see that the patient is ready for the initial examination. When the junior physician has finished writing the patient record, he or she changes the status in the same whiteboard column, so that the senior physician can see that the patient is waiting for examination. In our observations, both the junior and senior physicians used the whiteboard as the central artifact to get an overview of which patients were ready for examination.

Blood tests are typically ordered during the admission of a patient. From this point onward the blood-test process is temporally intertwined with the coordination and synchronization of ED work. Whereas blood tests are often ordered by nurses during admission, the test results should always be evaluated and electronically acknowledged by a physician. This means that the work with blood tests is a collaborative and multidisciplinary process. Those who order the blood tests are typically not the same as those who evaluate the results. The responsibility for attending to a patient's blood tests follows the patient's progression along the patient trajectory. The shadowed junior physicians stated that during their initial examination they were responsible for the patient and therefore also for following up on tests results. When they finished their task, the responsibility for the patient and for following up on blood tests shifted to the senior physician. During our observations we noted that even though the whiteboard in most cases showed the name of the responsible nurse, the name of the

responsible physician was not always displayed. We will return to this point later.

Ordering blood tests early to receive the results in time

The overarching temporal concern in ED work is to quickly reach a diagnosis and decision about the patient. This concern is dictated by the acute nature of the patient's condition. Blood tests are a central element in this diagnostic work and important to the physicians' work toward reaching a diagnosis and devising a plan for the patient. Consequently, the results of blood tests should be available as soon as possible. The ED has therefore implemented a practice wherein the admitting nurses order blood tests as soon as the patient is admitted to a room. To expedite this stage of the process the ED has predefined sets of blood tests in the laboratory system. The admitting nurse will look at the whiteboard to ascertain whether the patient is a medical patient or a surgical patient and order the associated set of blood tests. When a blood test has been ordered in the laboratory system, an icon (a drop of blood) appears on the electronic whiteboard. The icon has a blue label to indicate that blood tests are ordered.

In the case of a trauma patient, the ED has implemented a practice in which the secretaries are responsible for ordering a pre-defined set of trauma tests in the laboratory system. This allows time for the laboratory technician to be present in the ED to draw the blood as soon as the patient arrives. Thus, the severity of trauma cases warrants a temporal pattern in which immediate action receives priority over resources. The practice of expediting the blood-test process by having nurses and secretaries order the tests entails a conflict between the need for receiving results in time and the fact that ordering relevant blood tests requires knowledge about the patient's problem. The physician needs test results to learn what is wrong with the patient but relevant tests can only be ordered on the basis of at least some knowledge of what is wrong with the patient. The ordering of blood tests prior to examination, that is, while there has been little or no contact with the patient, entails a risk of ordering irrelevant tests. The nurses we observed acknowledged this uncertainty and stated that they compensated for it by ordering several sets when they were in doubt. The ordering of multiple sets of blood tests does not change the process for the individual blood test. It can, however, complicate the treatment of the patient because the relevant blood tests as well as those that are irrelevant (or no longer relevant) will appear in between each other on the whiteboard. On the whiteboard irrelevant tests are similar to relevant tests; the physicians must make and maintain the distinction mentally. It follows that when irrelevant tests are ordered, the physicians need to view and acknowledge tests of no clinical value. This may affect the general motivation for acknowledging test results.

The rhythm of drawing blood

When the admitting nurses order blood tests in the laboratory system, they are prompted to select the round on which the blood test should be taken. Most blood tests in the hospital are taken on rounds because rounds establish a temporal pattern that enables the medical laboratory technicians from the laboratory to organize their work efficiently. In the ED there is a round every hour on the hour. Once the blood has been drawn from the patient and arrives in the laboratory for analysis, the icon on the whiteboard turns from blue to yellow.

In critical cases the admitting nurse can order a blood test to be taken instantly rather than on a round. Each instant blood test must be manually initiated by the nurse by ordering it in the laboratory system as well as by phoning the laboratory. This process is necessary because instant blood tests follow a temporal pattern that overrides the standard organization of drawing blood on rounds. After phoning the laboratory the admitting nurse prints a copy of the blood-test order and leaves it for the laboratory technician in a tray outside the patient room. This way, the laboratory technician is freed from consulting the laboratory system before drawing the blood, thereby further expediting the process.

We observed several non-critical cases where the nurses tried to speed up the process by avoiding having to wait for a blood test to be taken on the next round. In one instance, a nurse expressed frustration because the time had just passed eleven, which meant that she missed the round. She then worked around this delay by finding the laboratory technician, who had started her round at the ED, and asking whether the test could be taken on the round. Once the laboratory technician had accepted, the nurse ordered the test in the system, printed the order, and left it in the tray outside the patient room. The admitting nurse's motivation for trying to speed up the process of drawing blood includes, as previously mentioned, that the results of blood tests are central to the diagnostic work. An additional motivation was mentioned by the nurse in her frustration over having missed the round: If she had to wait another hour to get the blood drawn, the test results would also arrive later, which in turn would delay the decision about whether the patient should be transferred or discharged. That is, missing the round would imply a delay regarding when the admitting nurse could get the room back. This motivation concerns another temporal pattern central to ED work; one that several of the nurses referred to as "securing the flow".

Receiving and attending to test results

When a blood test has been analyzed, the icon on the whiteboard changes colour. If the results are within the normal range the icon turns green, but if one or several of the test results are abnormal the icon turns red. If a test result is critical the icon flashes. The observed nurses were aware of the meaning of the different colours. We observed several instances of nurses noticing icons that indicated the arrival of new test results and then notifying the physicians about it. The physicians acknowledged that it quite often is a nurse who notices new test results on the whiteboard and then notifies a physician.

It is a constant concern in the ED to secure available beds for new patients, who may arrive at any time. In several of our observations, the nurses emphasized the importance of securing the flow of patients through the ED. This entails ensuring that the physicians can quickly devise a plan for each patient, so that the patients are either discharged from the ED or transferred to other departments. In some cases the decision about whether to discharge or transfer had to await the arrival of blood-test results. We observed physicians who wrote in the patient record that they would decide on further treatment once the test results arrived and, on other occasions, physicians who informed the admitting nurse that if the blood tests came back normal the patient could be discharged.

Because the nurses are aware that test results are often central to the physicians' decisions about patients, the nurses pay attention to the arrival of new test results. A nurse stated that she often tried to keep an eye on the icons on the whiteboard because she wanted to make a room available for another patient. Even though the icons on the whiteboard provide a way for the nurses to notice that new test results are available, the nurses

still have to remember and actively make time to look at the whiteboard to see whether an icon has changed colour.

The observed physicians also recognized the importance of securing the flow. After writing in the patient record that a patient should be transferred to another ward, a senior physician stated that she also wanted to inform the admitting nurse personally because there were few vacant rooms. Though the physicians recognize the importance of securing the flow, they mainly prioritize their patients according to how urgently they need treatment. This prioritization creates a temporal patterning that is related to the patients' triage level and must continually be reconciled with the other temporalities in the ED, such as securing the flow of patients through the ED.

Different temporal patterns are associated with different triage levels. Patients at level 3 must be seen by a senior physician within two hours after triage, whereas patients at level 2 must be seen by a senior physician within 10 minutes. A senior physician stated that it was not unusual to have up to three level 2 patients at a time. Another senior physician explained that frequent interruptions made it difficult for her to complete her tasks. In order to create some continuity in her work, she tried to finish examining one patient before attending to other patients. This, she stated, was her reason for not constantly keeping an eye on the whiteboard for new test results. A nurse stated that she regularly had to remind the physicians of level 3 patients. For her the whiteboard icons, which alerted her of new test results, provided an opportunity and a reminder to draw the physicians' attention to level 3 patients and in that way try to secure the flow of patients through the ED.

Because it is not known when test results will arrive, the observed clinicians acknowledged that the whiteboard at all times should show information about the nurse and physician responsible for each patient. This was however not always the case. In our observations, the nurses on several occasions had to ask around to identify the responsible physician, when they wanted to notify about the arrival of new test results because this information was not shown on the whiteboard.

Clinical work and the acknowledgement of test results

When test results are acknowledged by a physician, the icon on the whiteboard turns grey. It is a formal requirement that all test results are acknowledged. However, the work practices in the ED often dissociate the use of test results in the treatment of a patient from the acknowledgement of having seen the test results. Test results are rarely back when the junior physicians write the patient record. Sometimes a subset of the results have arrived before they finish writing and we observed junior physicians documenting these results in the record, but we never observed a junior physician acknowledging for the results. The reason they gave was that they did not want to acknowledge for a test, while some of its results were still missing. They would rather leave it for the senior physician to acknowledge the test once all results had arrived. This shows that the temporal separation between the junior physician's initial examination and the senior physician's examination means that test results can be used and even documented without being acknowledged, and that a subsequent acknowledgement will not be by the physician who used and documented the result.

In addition, test results are regularly examined at the daily timeouts, during which the physicians walk through the patients in the ED. At the timeouts junior physicians can seek advice on how to interpret test results and senior physicians give advice on additional tests to perform and possibilities to consider. The timeouts are held by the whiteboard, and when the physicians walk through the patients they repeatedly make reference to whiteboard information, such as the icons, and click on icons to view test results. Though test results are being viewed and evaluated during the timeouts, we never observed that tests were acknowledged during timeouts. Indeed, a chief physician stated that the tightly scheduled timeouts were not a proper occasion for acknowledging test results.

The Medical Department at which we made supplementary observations has implemented a separate temporal pattern specifically directed at ensuring that all blood tests are acknowledged. At the end of their shift the senior physicians are responsible for acknowledging all unacknowledged blood tests. In our observations, it did however on several occasions appear to be difficult for the physicians to relate the test results they were acknowledging to the treatment of the specific patient. Rather, it appeared as if the process of walking through the outstanding blood tests mainly served the purpose of the acknowledgement itself. The ED has not implemented a practice similar to that at the Medical Department, but relies instead on individual physicians' diligence in acknowledging test results in relation to their use. As described above, several temporal patterns work against this goal.

Discussion

A temporally and collaboratively complex process

We have shown that the blood-test process is both temporally and collaboratively complex. The process is intertwined with the temporal patterns involved in the coordination and synchronization of the multidisciplinary work related to the patient's trajectory through the ED. This collaborative process requires continuous synchronization to maintain the flow of work and patients and to ensure the return of blood-test results in time for the senior physicians' examination of the patients. Blood tests are important to two central temporal patterns in the ED: the treatment of the individual patient and securing the flow of patients. Whereas the physicians mainly focus on the first temporal pattern and use the test results as input to their clinical evaluation of the individual patient, the nurses mainly focus on the second and see the arrival of new test results as an opportunity to remind the physicians of patients that can be moved toward completion of their trajectory in the ED.

The role of the whiteboard in supporting complexity

The whiteboard supports the coordination of the work in the ED. However, whereas the icons on the whiteboard support an awareness of the progression of the blood-test process, the whiteboard does not always show who is responsible for following up on test results. When the laboratory calls the ED to inform about critical tests, or a whiteboard icon flashes, it is crucial that the whiteboard shows who is responsible for the patient, in order for the other clinicians to know whom to inform. This finding is consistent with the recommendations of Sittig and Singh [5]. According to Bardram [8], artifacts can support clinicians in creating an awareness of the activities of others and thereby provide instrumental coordination. We contend that the whiteboard presently could provide such instrumental coordination in the ED, but such use of the system would require greater diligence in updating the whiteboard with information about the responsible physician. When instrumental coordination is inadequate, communicative coordination will take over [8]. Although new test results are visualized by means of instrumental coordination in the form of

whiteboard icons, the nurses rely on communicative coordination to inform the physicians orally of new test results. When blood tests have to be taken instantly, procedures prescribe that communicative coordination should be used. Communicative coordination is also used when the flow through the ED is challenged; in such situations, the physicians orally informed the nurses of decisions about transferal or discharge – though the decision was also visualized on the whiteboard. In these situations, the instrumental coordination by the whiteboard was inadequate because a fast response had to be ensured.

Attending to the icons

Previous studies have shown that being alerted of new test results is a highly valued feature of information systems in an ED [3]. This is also true in our study. It is, however, surprising that the alerts primarily served the purpose of securing the flow of patients and were, therefore, attended to by the nurses. One explanation for this is that the nurses, in their efforts to secure flow, attend to the whiteboard more frequently than the physicians, whose main focus is patient treatment. Another explanation could be that the display of all blood-test results (relevant as well as irrelevant) on the whiteboard results in some alert fatigue. In their treatment of the individual patients, the physicians often used a computer to write the patient record, adjust medication, and various other tasks. In these instances it seemed rather effortless to check the laboratory system for new test results. Thus, attending to the icons on the whiteboard would introduce a new temporal pattern; a new activity the physicians must integrate into their activities. If the ED wishes for the physicians to take a more active role in ensuring the flow of patients, the physicians should be encouraged to attend to the icons when they consult the whiteboard for information about which patient to examine next. Alternatively, test results should be conveyed directly to the responsible physician, for example on a smartphone carried by the physician.

Limitations

In interpreting the results of this study it should be remembered that (1) the observations were somewhat limited in duration, (2) the observer did not have a clinical background, and (3) the chosen method of shadowing might have affected the workflow of the observed clinicians.

Conclusion

The physicians in the ED are expected to acknowledge test results in the course of their use of the results for diagnosing and treating the patients. This practice differs from the one in the Medical Department, where the physicians, in addition to the use and acknowledgement of test results on the ward rounds, are required to acknowledge all remaining test results by the end of their shift. It does not appear meaningful for the ED to adopt a similar practice, because the test results play different roles in the two departments. The practice in the Medical Department aims at noticing outliers compared to previous values. In the ED, the test results are used in the diagnostic work and form one of several sources of input that inform interpretation of each other and therefore must be simultaneously present to support the physicians in reaching a coherent understanding of the patient. If the activity of acknowledging test results is dissociated from the use of test results in reaching this coherent understanding, then the acknowledgement becomes a formal add-on of little clinical value. Our study shows that temporal dissociation is quite frequent due, for example, to the use of test results at timeouts without simultaneous acknowledgement. In addition, a number of tests are known to be irrelevant even before the results arrive because other developments have moved the diagnostic work in other directions.

Our results suggest that the ED needs to clarify who is responsible for following up on and acknowledging test results. The whiteboard could show this information, provided the clinicians keep the information about the responsible physician current as the patients' progress along their trajectory through the ED. In addition, the ED must promote awareness among the physicians of the challenges of temporally dissociating test use from acknowledgement. Formally requiring that all test results be acknowledged implies a need for further work on how best to integrate such acknowledgement in ED work.

Acknowledgements

This study was co-funded by Region Zealand as part of the Clinical Communication project. Thor Brygge approved the observations and interviews at the Medical Department. Special thanks are due to the observed and interviewed clinicians.

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Address for correspondence

Arnvør á Torkilsheyggi, Computer Science and Informatics, Roskilde University, Universitetsvej 1, Bldg 43.2, DK-4000 Roskilde, Denmark, email arnvoer@ruc.dk