

Research Article

Changes, disruption and innovation: An investigation of the introduction of new health information technology in a microbiology laboratory

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Abstract

Background: It is expected that health information technology (HIT) will deliver a safer, more efficient and effective health care system. The aim of this study was to undertake a qualitative and video-ethnographic examination of the impact of information technologies on work processes in the reception area of a Microbiology Department, to ascertain what changed, how it changed and the impact of the change. **Materials and Methods:** The setting for this study was the microbiology laboratory of a large tertiary hospital in Sydney. The study consisted of qualitative (interview and focus group) data and observation sessions for the period August 2005 to October 2006 along with video footage shot in three sessions covering the original system and the two stages of the Cerner implementation. Data analysis was assisted by NVivo software and process maps were produced from the video footage. **Results:** There were two laboratory information systems observed in the video footage with computerized provider order entry introduced four months later. Process maps highlighted the large number of pre data entry steps with the original system whilst the newer system incorporated many of these steps in to the data entry stage. However, any time saved with the new system was offset by the requirement to complete some data entry of patient information not previously required. Other changes noted included the change of responsibilities for the reception staff and the physical changes required to accommodate the increased activity around the data entry area. **Conclusions:** Implementing a new HIT is always an exciting time for any environment but ensuring that the implementation goes smoothly and with minimal trouble requires the administrator and their team to plan well in advance for staff training, physical layout and possible staff resource reallocation.

Key words: Computerized provider order entry, health informatics, laboratory information systems, microbiology laboratory

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BACKGROUND

Internationally, there is much emphasis placed on the

potential of health information technology (HIT) to deliver a safer, more efficient, and effective health care system.^[1] A review by Buntin *et al*, showed that although

recent evidence continues to show positive benefits of HIT,^[2] there is a need for studies that are able to document and address the challenging aspects of HIT implementation.^[2]

A recent Institute of Medicine report: Committee on Patient Safety and Health Information Technology Board on Health Care Services, Institute of Medicine, Health IT and Patient Safety: Building Safer Systems for Better Care 2011, Washington, USA, draws attention to the critical importance of technology and its interplay with people (e.g., clinicians, laboratory staff, patients) along with workflow processes and their environment.^[3] In light of the Institute's report, qualitative assessments can provide valuable empirical evidence about the context and processes that can affect (either positively or detrimentally) the successful and safe functioning of the new IT system.^[4]

Hospital microbiology departments provide an important example where new HIT is required to deal with complex work and information exchange processes.^[5,6] Microbiology departments have their own distinctive and context-dependent requirements associated with the study of diseases caused by infectious agents (e.g., bacteria, fungi and parasites).^[7] They also have unique workflow requirements which need to be aligned with the design and implementation of new HIT systems. While many hospitals are embracing new information technology, it is rare to share experiences or lessons learnt.

Workflow design is a key consideration for HIT implementation. New technologies can have a major impact on any number of factors including the way that professionals communicate and the type of information that is exchanged.^[8-10] Yet, despite this, most research on HIT does not concentrate directly on organizational workflows, and of those that do, there is considerable variation in the details provided about the work processes that are affected or that are required to change.^[11] Interview and focus group research are valuable research tools because they examine how people perceive and make sense of a situation. They are less useful for identifying what people actually do and how they perform their tasks.^[12] Observations of activities is a useful method because it does not rely only on what people say. It can be used to help understand the context and situation that people operate within.^[13] The combination of observation (ethnographic methods) with in-depth interviews and focus group can thus be used to identify how work tasks are modified to suit the contextual setting.^[14]

The aim of this study was to describe using video and qualitative accounts, the effect of a new HIT on work processes in the specimen reception area of a microbiology department, to ascertain what (if anything changed), and if so, what changed and what was its impact.

MATERIALS AND METHODS

Setting

The research was carried out during the period November 2005 to October 2006 at a microbiology department that was part of a pathology service located in a large 660-bed metropolitan tertiary hospital located in Sydney, New South Wales, Australia. The pathology service employed over 300 staff and services seven hospitals. The microbiology department employed over 50 staff and received approximately 131,000 test requests annually (450-500 requests per day).

Up until November 2005, the laboratory received handwritten requests on a generic request form which required listing the test required along with some basic patient demographics and any relevant clinical information. The request form also contained details of hospital, ward and information for billing purposes.

In November 2005 the existing laboratory information system (LIS) (known as Hosrep) was replaced by the Cerner Corporation (Kansas City, USA) PathNet system. In early January 2006 this was integrated into Cerner's PowerChart (version 2004.01) (Computerized Provider Order Entry [CPOE]) system which allows physicians to electronically transmit laboratory orders. Once CPOE was introduced there was a gradual conversion from handwritten forms to electronic entry but still accepting both electronic and handwritten request forms. Medical staff were the only ones with the authority to enter electronic requests. Training in the CPOE was provided to the medical staff by the hospital's information technology training group. Ethics approval (Human Research Ethics Committee [HREC] Project No. 2005/058) for this study was provided by the relevant Area Health Service HREC.

Study Design

The study consisted of qualitative (interview and focus group) data and observation sessions for the period August 2005 to October 2006 along with video footage shot in two sessions: (i) Hosrep (pre-Cerner) recorded September 2005) and (ii) PathNet (after the introduction of Powerchart) recorded in late January 2006.

Data Collection

The qualitative data consisted of 1 focus group (5 participants), 20 interviews (11 participants), and 8 observation sessions (total of 12 hours). All staff involved in the specific processes under investigation was involved in the process. Participants included two senior laboratory scientists, one business manager, three technical officers and five laboratory scientists. Participants were asked a series of semistructured questions which explored the advantages and disadvantages of the new HIT, how it had affected their work and the way they interacted with each other and how effective it had been. Transcripts of

the focus groups and interviews resulted in 34 transcript pages (A4 single spaced) which amounted to 14,625 words. Participants were purposively invited to participate in the focus group or interviews, based on their expertise and/or experience related to the work processes involved in the laboratory process and the changeover to the PathNet system.

Video footage was collected by a researcher with a hand-held camera. The purpose of the filming was to record the processes involved in how laboratory technicians and scientists in the specimen reception area of the microbiology laboratory dealt with test requests before and after the introduction of each of the new technologies. There were two video sessions recorded. The first session was recorded in September 2005 (44.52 minutes all in the specimen reception area) prior to the introduction of the HIT. The second session was recorded in January 2006 (1 hour 21.28 minutes with all but the last 25.32 minutes in specimen reception) 4 months after the introduction of PathNet including CPOE. All footage was analyzed and used to determine the various steps in the processes and the time taken to complete each step. Both data entry personnel were observed and their times recorded for the data entry of 10 specimens in both Hosrep and PathNet systems (with and without CPOE). The average time was recorded in the flow charts. Interviews and observations were ceased when the data reached the point of saturation (i.e., when no new information was emerging).

Data Analysis

The qualitative data analysis involved an initial identification of emerging themes from the data which were coded using NVivo software.^[15] These themes related to what work has changed, how it has changed, who was involved in these changes, and the circumstances in which these changes occurred.^[16] These themes were then subjected to further discussion

within the research team and to feedback sessions with laboratory personnel to aid the validation and assessment of the findings using respondent validation to enhance the validity of the data.^[17]

Iedema *et al*, used video footage in such a way as to allow participants to direct the focus, length, and intent of the session.^[18] The video footage focused on capturing the work processes associated with the handling of the specimen and request form once it arrived in the specimen reception area of the laboratory. Participants were able to highlight specific issues in the process that they thought were important. This process provided rich contextual data [Video stills in Figures 1 and 2] which provided the research team with the ability to observe and compare data across a number of dimensions including (a) the temporal flow (how long it took to carry out tasks); (b) the sequential order (how events were allocated and synchronized), and (c) the spatial coordination and performance of tasks. Data from the video footage were used to construct process maps to (a) characterize the different tasks involved; (b) identify the time it took to perform the tasks; (c) identify the sequence and flow for work and (d) describe any steps that may have been eliminated, changed or added in the course of the system implementation.

A grounded theory approach^[19] was used to identify emergent themes and the assignment of codes. These themes were iteratively developed through regular research team meetings to identify characteristics and relationships among the themes and to develop a deeper understanding of the changes in work process and the impact of these changes. This analysis was enhanced by a close working relationship with pathology personnel who in the course of the study developed into collaborators in the discovery and assessment of the analyses, while contributing valuable feedback to enhance the validity of our findings.^[17]



Figure 1: Video footage of the data entry area pre HIT change (HOSREP) – note the absence of “dirty” specimens in the “clean” work environment



Figure 2: Video footage of the same data entry area following the implementation of the HIT (PathNet) – note the presence of “dirty” specimens in the “clean” work environment

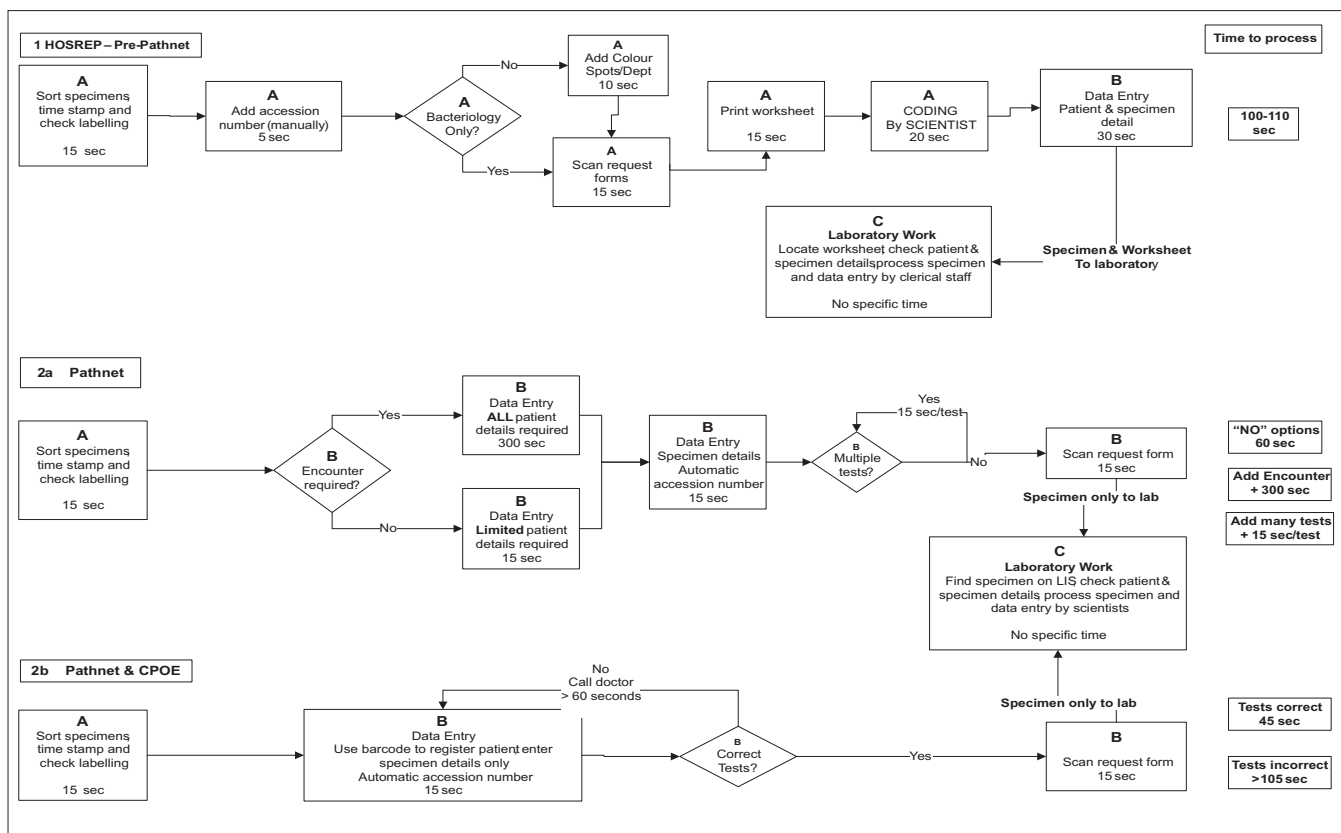


Figure 3: Flow chart

RESULTS

The video recordings captured the data entry processes used for microbiology test requests for each LIS. The first video recording in September 2005 was that of the existing LIS (Hosrep). The second video recording was of the new LIS (PathNet) and was recorded in late January 2006 after the implementation of Powerchart (CPOE) in early January 2006 which allowed clinical staff to electronically transmit their requests for microbiology tests. Prior to the introduction of Powerchart, requests were hand written.

Results describing changes in data entry work processes are presented in terms of three stages; "A" represents the pre-data-entry stage, "B" the data-entry stage and "C" the process in the laboratory. Documentation of the three stages is described in Table 1. Flow charts Figure 3 schematically describe the three request data entry processes in the laboratory: (1) represents the previous LIS (Hosrep), (2a) represents the new LIS (PathNet), and (2b) the new LIS (PathNet) in combination with Powerchart (CPOE).

Stage A – Predata Entry

From Table 1, it can be seen that a major difference between the predata entry stages of Hosrep and PathNet was the elimination of three pre-data entry steps and

the deferred processing of three other steps of Hosrep. All these steps in Hosrep were required to ensure the specimen had the correct tests ordered, the right billing codes documented and the appropriate processing steps printed onto the worksheet. A worksheet, with a copy of the request form, was then printed to ensure all relevant clinical data were available to the laboratory scientist. In contrast, PathNet had only one predata entry step since PathNet automated the previously manual steps of Hosrep. No printed worksheet was generated by PathNet.

The predata entry stage using CPOE was identical to the PathNet process. Scanning of the request form occurred in both Hosrep and PathNet (albeit at different stages of processing). The pre-data entry stages of HOSREP took on average 70-80 seconds per specimen whereas PathNet had only one step that took 15 seconds.

Stage B – Data Entry

The mean data entry time to completion in both Hosrep and PathNet were quite similar (30 and 45 seconds respectively). PathNet however had another level of complexity as more patient information was required relative to Hosrep. This information was required to be entered by data entry staff at each point of entry into the hospital by the patient (e.g., Admissions Office, Emergency Department, radiology, pathology, etc). If the patient presented to the pathology department, then it

Table 1: Summary of processes

Process	Pre-PathNet (HOSREP)	2a PathNet	2b PathNet and CPOE
Specimen receipt and sorting	Sort into four groups	Sort into six groups	Sort into six groups
A. Predata entry stage			
Time stamped	Yes	Yes	Yes
Check spec. labeling	Yes	Processed later	Processed later
Lab number applied to specimen based on group	Yes	Eliminated	Eliminated
Special section labels added according to tests requested	Yes	Eliminated	Eliminated
Request form scanned	Yes	Processed later	Processed later
Worksheet printed	Yes	Eliminated	Eliminated
Scientist checks tests requested, clinical notes and media to be used	Yes	Clerical staff (later)	Clerical staff (later)
B. Data entry stage			
Scan barcode Lab No. or patient label	Yes	Yes	Yes
Select encounter	No	Yes	No
Mandatory fields (patient demographics)	Yes	Yes	No
Mandatory fields (specimen related)	Yes	Yes	No
Test code for specimen	Done earlier by scientist	Done now by clerical staff	Performed by medical staff at CPOE (but may need correction by lab staff)
Sequential lab number	Yes	Random number	Random number
Print barcode labels	Pre-printed	Printed now	Printed now
C. Processing in lab stage			
Need form/worksheet	Yes	Eliminated	Eliminated
Data entry by clerical staff	Yes	No	No
Data entry by scientist	No	Yes	Yes
LIS downtime problems	No	Yes	Yes

was the responsibility of the pathology staff to complete this data entry. Study participants reported that patients presented directly to the pathology department in around 30% of cases and these data entry took an average of 5 minutes per specimen to complete (and sometimes longer if clinical staff had to be contacted for further information).

This extra patient information was not an issue for the laboratory with CPOE since all the relevant information had already been entered and was accessible as part of an electronic order. This simplified the data entry stage and reduced the time taken to complete to 30 seconds. However, other delays were experienced in the CPOE system if the physician requested the incorrect test (e.g., viral swab collected and bacterial culture ordered). Since the ordering physician was the only one that could change the order, laboratory staff was required to contact them to confirm the tests requested, cancel the incorrect order (not a simple process since because of the necessity to address billing requirements), and enter the correct test. This added another 60 seconds to the data entry stage. Previously with Hosrep, incorrect tests could be corrected by laboratory staff before data entry occurred.

When multiple tests were requested on the one specimen (e.g., a fluid specimen may require bacterial culture, TB

culture, viral culture and fungal culture) Hosrep was much faster than PathNet. The process in Hosrep was a simple matter of adding the extra tests in a test field. PathNet, however, required all the specimen information to be reentered for each requested test. This added a further 15 seconds for each subsequent test. So in the above example where there are four tests requested, data entry would take an extra 45 seconds (the first test included in the original data entry).

Some of the steps that were classified as pre-data entry steps in Hosrep were classified as data entry stages by PathNet. From the microbiology interview transcripts participants described how this required some reorganisation of the physical layout of the specimen reception area. More work space was required around the data entry computers so that trays and racks of specimens could be placed nearby for processing. This introduced issues of a cramped working environment with temporary desks and extra barcode printing equipment required for processing. Occupational health and safety issues were also introduced with the handling of potentially leaking or contaminated specimens in a previously “clean” work area. Figure 1 shows the original Hosrep data entry work area with no specimens near the “clean” work area and Figure 2 shows the new PathNet work area with extra equipment, desks, and contaminated specimens all in the one work area.

Stage C – In-laboratory Processing

The video footage showed that Hosrep required laboratory scientists to handwrite their results onto the worksheet and then submit a form back to the specimen reception staff for data entry (and checking of data entry by a supervisor). Since PathNet is a “paperless” system, results are entered directly in to the electronic patient record by the scientist performing the tests. These results are verified on screen by a supervisor. Study participants noted that the paperless system creates some potentially critical situations if the LIS or mainframe computer system is down. Results would always be available on the worksheet in Hosrep but with PathNet there is no way of issuing results or progressing the specimen any further without the information in the patient computer record (this situation is a rare occurrence but steps were under way to provide contingency processes for this eventuality).

Shift in Responsibilities for Specimen Reception Staff

Staff in specimen reception said that the major impact for them resulting from the change in LIS had been a shift in their responsibilities. With PathNet, clerical staff members were required to understand more technical aspects of the work of the department and to perform many of the tasks that were, with Hosrep, performed by the scientists such as coding and billing. This necessitated a large amount of training for the clerical staff in addition to the normal training required to learn the new LIS. Some of this training was scientific in nature and required some knowledge of microbiology. The complexity of the information needed to complete the data entry as well as issues of incorrect tests ordered by physicians was a significant shift in responsibilities for specimen reception staff.

Study participants noted that compared to Hosrep, extra staff was required to process the same volume of work for PathNet despite the fact that data entry of results required for Hosrep was no longer required. More time was required to enter the extra patient information as well as correcting test-orders incorrectly entered by physicians in the CPOE. This increased the workload to the point that an extra full-time equivalent staff member was required. On the figures provided, 30% of the 400 specimens received daily required the extra patient information to be entered. This was estimated to involve 600 minutes (120 specimens by 5 minutes) or 10 hours per day of someone’s time to look after data entry of extra patient information.

DISCUSSION

The introduction of the new information technology had a significant impact on the organizational functioning of the specimen reception area of the microbiology

department. The changes can be described in the following ways: (a) temporal (e.g., the time taken to process laboratory specimens); (b) spatial impact (e.g., the physical layout of the specimen reception area, (c) task and resource allocation (e.g., a shift in staff responsibilities alongside the need to reallocate staff resources).

Temporal Changes

The new computer system had many of the positive aspects that laboratories would expect from a new LIS. This included enhanced levels of system integration including access to previously unavailable patient information.^[20,21] This meant that clinical information critical to the interpretation of microbiology results (which previously may not have been provided by physicians) was now readily available.^[15] Another benefit was the elimination of many manual pre-processing steps that needed to be performed in the laboratory before data entry could be completed. This eliminated the need to search for forms/worksheets that on many occasions were misplaced. The gradual implementation of the CPOE system also led to a reduction in the time taken for data entry since most of the preliminary processing was completed in the wards by the requesting physician.

Spatial Changes

The physical layout of a work area before the implementation of a new HIT is also important to ensure that the correct work environment is available. In this case, there was a shift in emphasis from a central work area processing specimens (in a “dirty work area”) to smaller work areas around each data entry terminal (now “clean” and “dirty”). This required workstations to be setup (purchase of equipment) as well as rearranging furniture and benches. This finding highlights the importance of layout and design considerations as a means to optimize production and output.^[22]

Task and Resource Allocation Changes

The findings from this study illustrate the great potential for new HIT systems to affect how work is distributed and collaboratively undertaken.^[23,24] In this study, clerical staff was required to have a better understanding and knowledge of scientific and medical terminology. This is not a process that can happen overnight and a significant lead up time is required to prepare staff for these extra responsibilities. This underscores the need for laboratory administrators to be aware of and plan in advance the training of staff.

LIMITATIONS

This study used qualitative methods (interviews and focus groups) and video ethnography to examine the impact of a new HIT system on the specimen reception area of the microbiology department. Such methods

can help to provide a rich contextual understanding of the issue at hand, but may not be able to provide a summative evaluation nor can the results be generated to all situations which are contingent on the specific point under investigation. Nevertheless the combination of qualitative interviews and focus groups and video ethnography did have the advantage of not only exploring how the HIT system was seen by laboratory users but also how it was used by people to provide valuable information.^[25]

CONCLUSION

Implementing a new HIT is a challenging prospect for any environment, but ensuring that the implementation goes smoothly and with minimal interruption requires careful planning well in advance for staff training, physical layout, and possible staff resource reallocation. This usually involves the complex task of making sure that the interests of all stakeholders are aligned.^[8,26] Failure to achieve alignment can lead to major tensions and persistent problems. The identification of evidence of these difficulties and the potential solutions is therefore of utmost importance.^[10,27]

COMPETING INTERESTS

There are no competing interests in this study.

AUTHORS' CONTRIBUTIONS

G.T. played the lead role in drafting the paper. A.G. was primarily responsible for acquiring the data. All the authors were involved in the conceptualization and design of the study and in the analysis and interpretation of the data. All authors also played a role in the critical revision of the paper for its intellectual content and final approval prior to submission.

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