White Paper

Comparative Appraisal of the Nepean Emergency Department Information Management System (NEDIMS) versus a Clinical ERP system (CERP)

Extended Abstract

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The scientific report of this work is

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Study objective: This investigation was initiated after the introduction of a new information system into the Nepean Hospital Emergency Department. A retrospective study determined that the problems introduced by the new system led to reduced efficiency of the clinical staff, demonstrated by deterioration in the emergency department's (ED's) performance. This article is an investigation of methods to improve the design and implementation of clinical information systems for an ED by using a process of clinical team–led design and a technology built on a radically new philosophy denoted as emergent clinical information systems.

Methods: The specific objectives were to construct a system, the Nepean Emergency Department Information Management System (NEDIMS), using a combination of new design methods; determine whether it provided any reduction in time and click burden on the user in comparison to an enterprise proprietary system, Cerner FirstNet; and design and evaluate a model of the effect that any reduction had on patient throughput in the department.

Results: The methodology for conducting a direct comparison between the 2 systems used the 6 activity centers in the ED of clerking, triage, nursing assessments, fast track, acute care, and nurse unit manager. A quantitative study involved the 2 systems being measured for their efficiency on 17 tasks taken from the activity centers. A total of 332 task instances were measured for duration and number of mouse clicks in live usage on Cerner FirstNet and in reproduction of the same Cerner FirstNet work on NEDIMS as an off-line system. The results showed that NEDIMS is at least 41% more efficient than Cerner FirstNet (95% confidence interval 21.6% to 59.8%). In some cases, the NEDIMS tasks were remodeled to demonstrate the value of feedback to create improvements and the speed and economy of design revision in the emergent clinical information systems approach. The cost of the effort in remodeling the designs showed that the time spent on remodeling is recovered within a few days in time savings to clinicians. An analysis of the differences between Cerner FirstNet and NEDIMS for sequences of patient journeys showed an average difference of 127 seconds and 15.2 clicks. A simulation model of workflows for typical patient journeys for a normal daily attendance of 165 patients showed that NEDIMS saved 23.9 hours of staff time per day compared with Cerner FirstNet.

Conclusion: The results of this investigation show that information systems that are designed by a clinical team using a technology that enables real-time adaptation provides much greater efficiency for the ED. Staff consider that a point-and-click user interface constantly interrupts their train of thought in a way that does not happen when writing on paper. This is partially overcome by the reduction of cognitive load that arises from minimizing the number of clicks to complete a task in the context of global versus local workflow optimization. [DOI:10.1016/j.annemergmed.2014.05.032]

Extended Abstract

This white paper is an investigation of methods to improve the design and implementation of clinical information systems (CIS) by using a process of Clinical Team Led Design (CTLD). It is argued herein that Best-of-Breed clinical information systems enable more efficiencies in the workplace than clinical enterprise systems (CERP), also known as the EMR.

An important aspect of clinical care is the need to change workflows and operating procedures as the environment around the work changes either due to new professional practices or shifting regulatory and administrative requirements. Hence, an ability to perform Continuous Process Improvement (CPI) is fundamental to the good practices of a clinical team. Rigid CERP systems that are slow and highly expensive to change are a significant sea anchor in the pursuit of CPI and frustrate staff to the limit of their patience.

A technology has been created that supports a methodology for creating user designs with an incremental iterative feedback process. In this technology, an underlying software engineering architecture, we denote as Emergent Clinical Information Systems (ECIS), automatically compiles the run-time code directly from the user designs, hence no programming is required to move from design to implementation. The ECIS architecture is defined on the principle of *Ockham's Razor of Design*, that is, the elements of design that are engineered for the designer are a minimum number of design objects with maximal generalisation. The CIS design is created by a principle of *Agile Design* where designs are created and tested incrementally within an iterative process.

With this functionality, the capacity to make near real-time adaptation of an implementation is made available, giving enormous power to the design team to explore alternative designs before commissioning a specific implementation. At the same time, the underlying data management for all CISs built in the ECIS paradigm is the same, and hence it has the unification of the code base and data stores in a single application. In essence, it is a Best-of-Breed solution on the user side and an enterprise system on the server side.

The ECIS model with real-time changeability, native interoperability to move data to where it has to be used, and in-built analytics to monitor the effect of change represents a much superior approach to providing effective methods for CPI in any clinical setting. As a technology, it is ideally suited to the creation of a CIS for any clinical specialty.

A local clinical team at Nepean Hospital, Sydney, Australia, designed a CIS for their hospital emergency department, denoted the Nepean Emergency Department Information Management System (NEDIMS). Its performance was compared to the incumbent CERP, FirstNet (FN) of the Cerner Corporation. This study takes the position that the offerings of all EMR solutions of the major HIT

vendors suffer the same deficiencies compared to our ECIS solution and so we would generalise the results in this paper to all such EMRs. It is happenstance that in our context the FirstNet implementation was available for comparison.

The project had the objectives:

i. Assess the capacity of staff to design their own CIS;
ii. Assess the capacity of the ECIS technology used for the design process to satisfy all the demands of the design team;
iii. Assess the differences between the NEDIMS and the CERP for:
    a. Efficiency of operation;
    b. Cognitive load;
iv. Assess the effect of the clinicians' design on:
    a. Workarounds;
    b. Paper processes;
v. Assess the trainability of NEDIMS;
vi. Build a model of patient journeys and assess it for differences between NEDIMS and the CERP for that model;
vii. Identify the processes of interruptions and consider methods for minimising them.
viii. Make a qualitative assessment of the differences between the two systems for patient safety, staff productivity and clinical audit;
ix. Assess the costs and ease of modifying the system and provide an evaluation of the ROI in making those changes.

A process analysis for each of the 6 activity centres in the ED is described: Clerking, Triage, CIN (Clinical Initiatives Nurse), Fast Track, Acute Care, and Nurse Unit Manager (NUM). The process analysis formed the basis of understanding the design needs of the department. It was also used subsequently to identify the task types that needed to be used in the quantitative comparison between the two systems. A total of 43 task types were identified of which 27 were present in the CERP system, 40 were present in NEDIMS and 14 were completed on paper.

The department staff were observed for 22 days where each task instance was measured for time duration and number of mouse clicks in live usage on the CERP and paper forms. A total of 722 task instances were recorded from 43 task types. Subsequently, 374 matched observations of 17 task types were measured for those tasks that could be repeated in NEDIMS of which 332 were matched task instances between NEDIMS and the CERP, the remainder being matched to paper forms.

Objective 1. In the design phase, the project consisted of fortnightly to monthly meetings over a period of a year of a small clinical team and process analysts. The project progressed by discussing the additions and changes made to the system since the previous meeting and then bench testing what was new about the system. Changes were validated or rejected depending on the effectiveness of the implementation. The clinical team learnt that not everything they thought they wanted is actually what they needed as requested implementations were sometimes rejected in subsequent testing.

An analysis of the design trade-offs of workflow between a local disadvantage versus global gain showed that staff will consider patient safety and auditability to be equally important in the design of a system as efficiency, and will sacrifice the latter for the former where considered appropriate. This reinforces the importance of creating designs that match clinical values as much as operational efficiency, and that staff conscientiousness will lead to a higher level of criticism and frustration if these values are improperly or inappropriately discarded in a system design.

Objective 2. The design technology was able to produce all practicable processing requested by staff. The design functions delivered included separate tracking lists by location and/or patient disposition status, triage, clerking, nursing assessments and tasks, clinical documentation, disposition, handover, vital signs, and reporting. Discharge summaries were automatically populated from other parts of the records. Connectivity to radiology and pathology systems was defined as out of scope. A number of current paper processes including CIN, medical certificates and prescription forms were incorporated. Extra innovations were introduced including graphing of vital signs, a ward map with multiple patients admissible to a bed to support care planning, FAQ for each patient showing their most important information, handover functions, and patient care summaries.

Objective 3a. The results of a quantitative study show NEDIMS is about 40% more efficient than the CERP using directly measured times, and on normalised results greater than 50% more efficient. NEDIMS was better on 14 out of 16 tasks for time costs of which 7 were statistically significant for NEDIMS and 2 were significantly better for the CERP.

Objective 3b. Cognitive load, as represented by click counts, showed that NEDIMS significantly reduced cognitive load for users by up to 30% overall. In 9 out of 16 tasks, NEDIMS had fewer clicks of which 5 were statistically significant with 5 significantly fewer for the CERP.

A further differential analysis was performed with adjustments to the clicks counts based on one hypothetical change to each system. It showed that fewer clicks in NEDIMS was statistically significant compared to the CERP on 3 tasks out of the 7 effected by these changes, and the two systems were equivalent on 3 of the other tasks while the CERP remained better at a statistically significant level on only one task. The change to NEDIMS was automatically loading current time and date values into forms without needing to click in the fields, which reduced the number of clicks, and, the hypothetical change to the CERP was to make it conform to an extra step for saving records as demanded by the clinicians to improve patient safety and auditability as designed in NEDIMS.

A detailed analysis of each task investigates the considerations that create the efficiency and cognitive differences.

Objective 4a. A number of workarounds discovered in the process analysis phase of the research were identified and the efforts to eliminate or minimise them in NEDIMS revolved around the current workflow processes of the department. For instance, terminals are used by multiple staff but they often leave the terminal due to interruptions or to collect other information. When they return to the terminal, they assume that the current session is under their own account when in fact, in the time of their absence from the terminal, another staff member has switched accounts. The first user continues entering data into a patient record without realising they are working under the name of a different staff member, which becomes apparent when they have to commit the record for saving and they do not have the password of the logged on user. As a result, they sometimes need to re-do potentially long tasks such as ordering tests after restarting the system with their own credentials. NEDIMS implemented a validation step of "signing off" that allowed switching accounts. More workarounds are discussed in the full report.

Objective 4b. The paper processes consisted mostly of nursing activities. The principal activity was that of the CIN, where the CIN paper form needed to be completed, but also a related electronic task on the CERP system in order to log the time it was completed as it controlled a specific Key Performance Indicator (KPI). NEDIMS integrated the paper form, auto-populating it where applicable, and directly linking the KPI to the processing of the integrated CIN form thus eliminating a number of duplicate tasks in the process.

Objective 5. Trainability was assessed by a bench test that was set up to evaluate the design at a late stage. About 20 staff were given individual training sessions on NEDIMS and asked to perform a range of data entry and data retrieval tasks. A training time of 5 minutes was set aside for each staff member. Training involved taking staff through the general architecture of the system followed by a Q&A session and self-driven exploration. No staff used up the full schedule of 5 minutes and all were able to complete nearly all the tasks. A subsequent qualitative survey was conducted to get the opinions of the staff about their sense of usability of the system which was overwhelmingly better than the CERP system.

Objective 6. A model of patient journey through the department consisted of 4 scenarios of short and long Fast Track patients and short and long acute care patients in a proportional ratio of 15:15:30:30. The resulting analysis showed that NEDIMS would provide a staff time saving of on average 23.9 hours per day.

Objective 7. An auxiliary study on the cost of interruptions showed that they amounted to greater time than to complete the interrupted task. A method of decreasing the interruptions by providing a new functionality in NEDIMS was to insert an FAQ button for patients as a quick access mechanism to critical information commonly requested in interruptions. The process of identifying the FAQ requirements aided the clinical team in discovering the type of information that is, in fact, not recorded anywhere including the CERP system, resulting in increased interruptions to obtain that information verbally.

Objective 8. A qualitative analysis was made by informally collecting opinions from staff comparing the two systems on 3 key performance criteria of Patient Safety, Staff Productivity and Clinical Audit over 19 tasks, giving a total of 57 cases. It showed NEDIMS was ranked higher on 39 cases, the CERP for 2 cases; the two systems were equal for 15 cases with one case non-determinable.

Objective 9. Some NEDIMS tasks were remodelled to demonstrate the value of feedback to create system improvements and the speed of iterative design in the ECIS approach. The time cost of the effort in remodelling the designs showed that the time savings are returned with a few days to a week of operations in the department; hence the return-on-investment has a high yield under the CTLD methodology. The total cost of designing and testing NEDIMS amounted to about 140 person days, which will be regained by the department after about 50 days of operations.

Conclusions

The results from this study support the opinion of the clinical staff engaged in the design and testing processes, that as NEDIMS reflects their local workflow processes, it ensures it is better suited to their needs and will be a better aid to their work than the incumbent CERP system.

The results of this investigation support the proposal that information systems designed by a clinical team using a technology that enables real-time adaptation provides much greater efficiency for the staff in an Emergency Department in decreasing the time to complete standard tasks. Additionally, it creates a continuous process improvement environment that enables the workflow processes to be adapted dynamically to optimise that efficiency improvement, and the ECIS technology enables measurement and recoupment of the costs of supporting the ongoing adaptation of these processes. The methods of the ECIS approach enable an estimate on return on investment, so given the total staff time cost to build all of NEDIMS was about 140 person days, and that NEDIMS is estimated to save the Nepean ED 24 hours of staff time per day or 3 person shifts per day, then the total effort expended in creating and testing NEDIMS will be recovered in about 50 days of operations of the department.

Our ECIS model of system development posits that a system is never “truly complete” but rather it is evolutionary, being stable for certain constraints and time and then changes in the clinical ecology around it. Just as we understand the world is constantly changing, so adaptability in a system is at least as equally desirable an attribute as efficiency, because even the most efficient system will eventually become mismatched to its environment and context of use if it cannot quickly, easily and cheaply adapt. Hence, the point in time when a system should be commissioned is when the community of users believe it can give them efficiency gains without unacceptable negative downsides. From that point on, it needs to be added to at will with few barriers to managed evolution. Indeed, the community of users can reliably identify the next most valuable activity to computerise in order to gain the maximum efficiency given their system's current capabilities. Such decision-making makes for an orderly and systematic progression in computerising their work activities. Hence, the ECIS model is a new paradigm, a credible alternative to a large-scale sudden-death system changeover using many foreign, impractical workflows. It capitalises on local knowledge and wisdom, flexible work practices and heuristics, and optimises the local environment in contrast to clunky, slow moving enterprise solutions.