Implementation of an Electronic Logbook for Intensive Care Units

C. Jane Wallace[1, 3], RN, Ph.D.; Dennis Stansfield[1], B.S.; Kathryn A. Gibb Ellis[1, 2], B.S.;
Terry P. Clemmer[1, 2], M.D.
(1) Department of Critical Care Medicine; LDS Hospital, Salt Lake City, UT
(2) Department. of Medical Informatics, University of Utah, Salt Lake City, UT
(3) Department of Medical Informatics, Intermountain Health Care, Salt Lake City, UT

ABSTRACT

Logbooks of patients treated in acute care units are commonly maintained; the data may be used to justify resource use, analyze patient outcomes, and encourage clinical research. We report herein the conversion of a paper-based logbook to an electronic logbook in three hospital intensive care units. The major difference between the paper logbook and electronic logbook data was the addition of clinician-entered data to the electronic logbook. Despite extensive computerization of patient information extant in the participating units, there was considerable reluctance to replace the paper-based logbook. The project's success can be attributed to the use of feedback from the clinical users in the development and implementation process to create accessible, high quality data. These data provide clinicians with the capability to monitor trends in a variety of patient groups. Advantages of the electronic logbook include more efficient data access, higher data quality and increased ability to conduct quality improvement and clinical research activities.

INTRODUCTION

Paper-based logbooks used for documenting admission, discharge, demographic, and diagnosis data are commonly used in a variety of acute care settings[1-6]. The retrieval of data maintained in paper form is tedious and time-consuming, and limits the value of the paper logbook. Few reports of computerizing the process of paper logbook data collection in the acute care setting exist[4, 5]. In our hospital, the paper logbook is still maintained on the majority of acute care units. One might argue that centrally maintained hospital financial or other administrative databases preclude the need for locally maintained databases. However, it is also reasonable to suggest that locally maintained databases can provide more accurate, complementary information than is available in central databases[3]. We reasoned that making use of our existing hospital information system (HIS) to record data normally collected by clinical staff in a paper logbook would allow much more efficient access to the data for a variety of clinical and research purposes. We report the development and use of an electronic logbook in three hospital intensive care units (ICUs).

DEVELOPMENT

Development of the logbook prototype started in March 2000. The host system for the electronic logbook is an extensively developed hospital information system (HELP[7]) running on a Tandem computer. PCs running a screen emulator are used as local terminals. The programming language, (PAL[8]), was developed uniquely for the HELP system.

The participating intensive care units were a 12-bed shock-trauma respiratory unit, a 16-bed general medical surgical unit, and an 8-bed respiratory special care unit. Development steps included: 1) workflow analysis of the paper logbook data collection process and data use; 2) functional specifications for the electronic logbook; 3) implementation; 4) data verification; and 5) report production and verification.

Workflow Analysis: Figure 1 illustrates the paper logbook data collection process and data use. The most notable inefficiencies in the workflow included: 1) redundant recording of already available electronic data on paper; 2) missing or erroneous data due to recording errors; 3) illegible handwriting; 4) illegibly stamped labels; 5) unnecessary duplication of data entered into a separate electronic data file without a data validation process; 6) lack of a reliable diagnosis; and 7) the need for manual review and extensive cleaning of redundant electronic data for both clinical and research purposes. Despite the inefficiencies, there was considerable reluctance to replace the paper-based logbook.

Functional Specifications: Functional specifications were tailored to reduce redundant data collection and enhance access to high-quality data. The developers intended to better use the HIS, the existing data collection process, and bedside clinical expertise to collect data with minimal additional work on the part of clinical staff. The concept of computerizing the paper logbook was met with skepticism when first presented to clinical leaders. Despite misgivings, the unit directors agreed that if the electronic logbook provided easy access to accurate data the paper logbook could be replaced. Figure 2 illustrates the electronic logbook data collection process currently

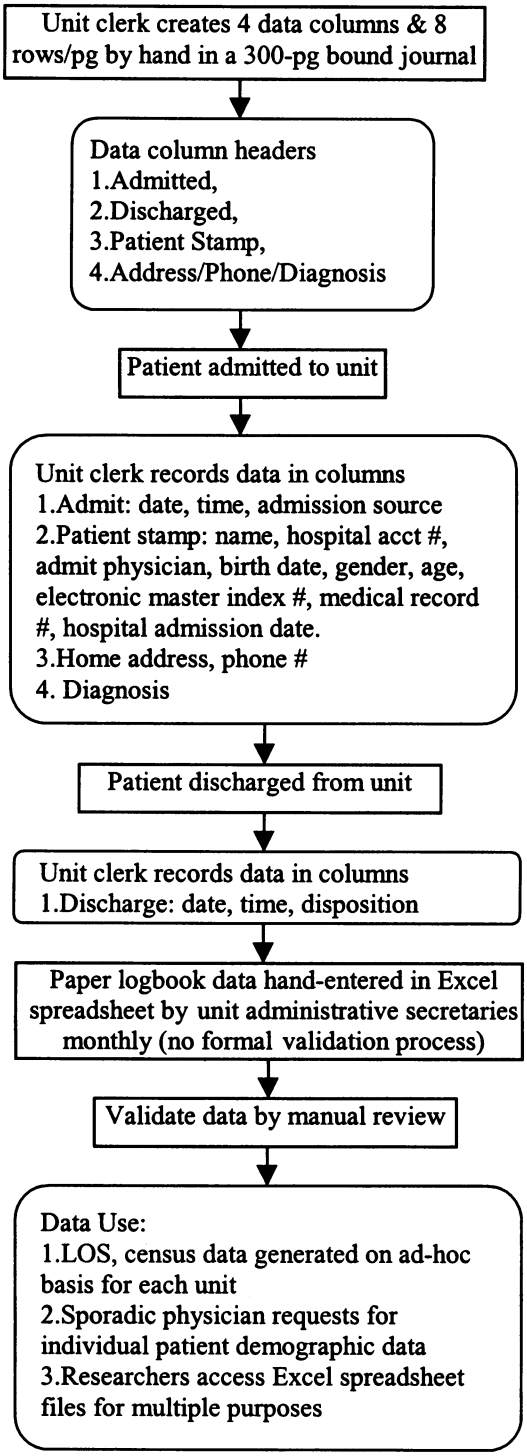

Figure 1. Paper Logbook Data Collection & Use

in use. The major difference between the paper logbook and electronic logbook data was the clinician-entered data in the electronic logbook. Clinician-entered data included ICU admission diagnosis (defined as the single major reason for ICU

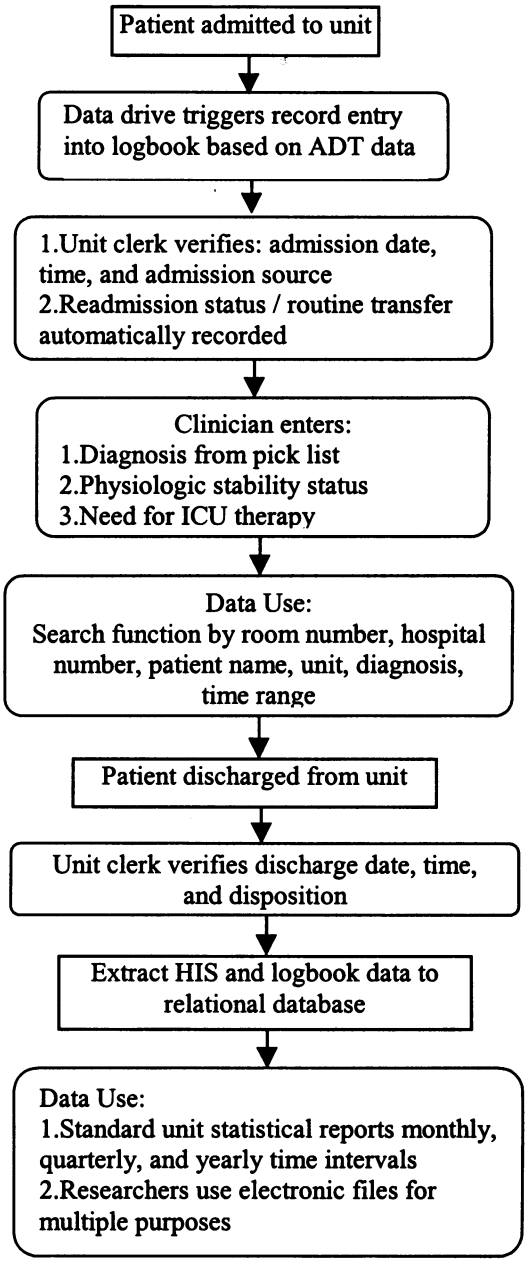

Fig 2. Electronic logbook data collection & use

admission), and a dichotomous answer (Y/N) to two questions: 1) Is the patient physiologically stable on admission? and 2) Is ICU therapy required? The definitions for clinician-entered data (available upon request) were adapted from relevant literature[9] and subsequently determined by local expert consensus. The ICU admission diagnosis consisted of a set of major categories and associated subcategories. Initially, there were 14 major categories and 81 subcategories. Analysis of a frequency distribution of diagnosis data after the first nine months of data

collection resulted in the current set of 12 major categories and 53 subcategories (Table 1).

Major Categories (N subcategories)
Cardiovascular (9)
Respiratory (10)
Gastrointestinal (8)
Neurologic (9)
Sepsis (1)
Trauma (2)
Renal (3)
Metabolic (4)
Hematologic (2)
Post-operative complications (3)
Other Surgical (free text)
Other Medical (free text)

Table 1. ICU Admission Diagnosis Categories

Implementation: The implementation process employed iterative software development guided by feedback based on actual use of a prototype in the clinical environment[10]. Beta testing occurred in May-September 2000 and refinements have continued to date. During the entire development process, both the paper-based and electronic logbooks were maintained in all three ICUs. Resources required to implement the logbook are outlined in Table 2. Ongoing yearly maintenance, which includes programming requested changes, report generation, and ad-hoc data requests requires about 145 hours of programmer time ($7482) and 65 hours of administrative assistant time ($1170).

Task	Hours	Cost
Design	100	$ 3,600
Programming	440	$ 22,704
Test/debug software	160	$ 8,256
Data verification	160	$ 8,256
Reports (write/test/debug)	320	$ 16,512
Training	52	$ 1,248
Total	1232	$ 60,576

Table 2. Resources to Implement the Electronic Logbook

Issues addressed during beta testing included program design and staff education. The initial program design elements that changed during implementation were diagnosis data, screen interface reminders, editing functions, and required data elements. The original specifications included capturing hospital and ICU admission diagnoses that could be associated with up to four secondary diagnoses. Ultimately, the decision to define and capture a single ICU admission diagnosis was based on clinician needs for expediency and to simplify data analysis. The ability to enter a free text diagnosis is available but is discouraged in favor of coded categorization whenever possible to preserve data quality. Screen interface reminders provide a visual prompt to staff when patient data are incomplete. Screen typeface is white before the clerk completes initial admission data verification, blue typeface indicates clinician-entered data are missing, and yellow typeface indicates all admission and diagnosis data are complete. The following editing functions were inadvertently omitted from the design specifications, but most were included in the initial prototype: 1) adding and deleting patients, 2) editing admissions source, 3) editing patient names (when an alias was assigned on admission), 4) editing the readmission data flag, and 5) ability to edit the room number when patient transfers occurred within the unit. All clerk and clinician-entered data elements are required to be complete before discharge information can be entered.

Staff education methods included a one-page written instruction set, a detailed instruction manual, formal in-service, staff meeting presentations, one-on-one sessions with clerks and clinicians, and 24/7 on-call support throughout the implementation process. The electronic logbook users include 22 clerks, 5 physicians, and 38 charge nurses. Estimated time spent in initial one-on-one training was 15 minutes per user for a total of about 16 hrs. Instructional material preparation required about 25 hours; staff meeting presentations required about 9 hours (1.5 hours per unit at the beginning and end of the development period). Early in the implementation process, the on-call pager call rate was about 2 calls/day; after the first few weeks the call rate decreased to 2 calls/week. The current calls (about 1 call/month) primarily reflect ongoing training issues. Total on-call time required to answer calls during the entire development process was approximately 4 hours.

Data Verification: Despite the fact that computer use is integral to workflow in our ICUs, clinical staff mistrusted the electronic data and thus maintained both the paper logbook and the electronic logbook for eighteen months between May 2000 and December 2001. Consequently, extensive validation of the electronic logbook data occurred daily during early implementation and monthly thereafter. Monthly comparisons between the electronic and paper logbooks were completed in 2001 for the medical-surgical ICU and an "average error rate" calculated for the year. The medical-surgical ICU comparisons probably reflect the "worst case" scenario of the three ICUs because unit volume and patient turnover is

highest there. Discrepancies between the paper and electronic logbooks were defined as errors with the assumption that the paper logbook was the "gold standard". Error rates were calculated as follows: 1) any error(s) in the electronic logbook (n patients with any error(s)/total n patients in paper logbook); 2) non-duplicate error(s) (n patients with any error(s) except for duplicate entry/total n patients in paper logbook); and 3) missing patient errors (n patients missing from electronic logbook/total n patients in paper logbook). An average error rate for 1) any error was 4.3% (68/1588), 2) non-duplicate errors were 2.8% (44/1588) and 3) missing patients was 2.0% (31/1588). Missing patient errors for the shock-trauma respiratory ICU in 2001 was 1.9% (15/784). For the month of December 2001, just prior to elimination of the paper logbook, the missing patient rate for all three ICUs was 1.2% (3/255).

Report Production and Verification: Standardized report specifications were approved for all units and were verified during January-December 2001 to ensure report accuracy. Verification included comparisons of the following data elements from the shock-trauma respiratory ICU in 2001 (n=paper vs. n=electronic): total number of admissions (n=784 vs. n=769), ICU deaths (n=116 vs. n=116), hospital deaths (n=144 vs. n=150) re-admissions, defined as readmission to an ICU after discharge from the same ICU during a single hospital stay (n=22 vs. n=23), readmission rate (2.8% vs. 2.9%), average patient census (n=9.0 vs. n=8.71), ICU length of stay (LOS) (n=4.2 vs. n=4.2). The comparisons, while not perfect, were within acceptable limits. Other data reported for each major diagnostic category, include: ICU and hospital LOS, crude ICU and hospital mortality, number and percent of patients with physiologic instability and who required ICU therapy.

The information in the reports and the anticipated research queries into the logbook required a relational database design. However, the HELP system lacks the qualities of a relational database. Therefore, data are downloaded from the HELP database to a relational database to produce standard reports and to support research queries. If modifications to the logbook data occur, only the HELP data files are altered and subsequently downloaded to the relational database in order to ensure the integrity of the logbook data.

Although the HELP system lacks relational database capabilities, predefined search options provide users the ability to find individual patients or patient groups from HELP system terminals. The user can choose to apply a time range to search for: patient name, unit, unit and name, hospital account number, and diagnostic subcategory. Answers to questions such as "When was John Doe last in the ICU?" and "How many patients were admitted during X time period?" are readily available.

IMPLICATIONS

Advantages of the electronic logbook include more efficient data access, higher data quality and increased ability to examine a variety of local practice patterns. Clinical outcomes research and process improvement activities are increasingly important in the health care settings. The acquisition of high quality, accessible clinical data is one of the significant barriers encountered in the quest for clinical practice improvement. The need for cost efficient efforts to construct and maintain high quality databases to enhance clinical quality improvement and outcomes research activities cannot be overstated.

Several issues are worth noting in the implementation of the electronic logbook. First, simple awareness of inefficiencies in the paper logbook data acquisition and management process did not provide adequate motivation for change. The developers had to convince the users that the electronic logbook would provide tangible benefits without disrupting workflow and without losing data. The decision to discontinue use of the paper logbook was up to clinical leaders; developers focused efforts on verifying and demonstrating the benefits of the electronic logbook data. Considerable effort was required before clinicians were willing to relinquish the paper logbook. One can only speculate why, in an environment where computers are extensively integrated into the clinical setting, the incongruous activity represented by the paper logbook was extant. Second, the success of the project is largely attributable to the prototyping and feedback from the clinical users in the development and implementation process. Carefully constructed design specifications were changed as a result of prototype software use under usual clinical conditions. Users accept change more readily when they actively influence the change process. Third, adequate resources and long-term commitment to the project were available. The resources necessary for implementation and ongoing maintenance might seem excessive at first glance. If one considers the long-term nature of the database and more efficient access to higher quality data, the return for the initial and ongoing resource outlay is easily offset.

Unit directors are enthusiastic about the electronic logbook data. Benefits for the respiratory special care unit accrued during the 2002 budget process. Financial data used by budget planners substantially underestimated length of stay when compared with electronic logbook statistics. The respiratory special care unit nurse manager used the electronic logbook data to challenge the financial data and justify an increased FTE budget for 2002. For the medical-surgical ICU, the data were used to justify hiring an additional unit clerk for the night shift. Other ad-hoc data requests received for the medical-surgical ICU since January 1, 2002 include: 1) the top admitting diagnosis; 2) peak admission time by weekday to aid in decisions regarding allocation of staff resources; 3) frequency of patients with medical vs. surgical diagnosis; 4) frequency of patient discharges by location; 5) patient flow (total admissions and discharges in a designated time range), and 6) length of stay by diagnosis and admitting physician. For the shock-trauma ICU, the logbook data have proven useful in planning for anticipated volume in a separate neuro-trauma ICU.

The success of the electronic logbook project does not preclude the need for ongoing maintenance and refinement. The developers are committed to continuous improvement of data quality and accessibility; current work is focused on decreasing the missing patient error rate to <0.5%. Initial and ongoing training needs include clarification of electronic logbook definitions and rules for assigning diagnostic categories. Previously, paper logbook diagnoses had been informally assigned and recorded by unit clerks. These diagnoses were considered unreliable and therefore were not useful for clinical or research purposes. Coded categorization of diagnoses and use of bedside clinical experts to assign diagnoses have theoretically improved reliability; however, formal reliability assessment is currently in process for clinician-entered data. Other future development plans for the electronic logbook include migration to a Windows/web based environment, elimination of the redundant database structure, refining name search options and their associated aliases; and generating risk-adjusted mortality statistics for high frequency ICU admission diagnoses. It has also been suggested that the electronic logbook be implemented in other units and hospitals within our health care delivery network.

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