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ORIGINAL

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Impact of an electronic information system on physician workflow and data collection in the intensive care unit

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Abstract *Objective*: To test the hypotheses that: (1) integrating information processing tasks using an electronic clinical information system (ECIS) decreases time to complete these tasks by hand; and (2) structured data entry encourages generation of more detailed records and capture of specific data elements even when entry is voluntary.
Design: Prospective observational time analysis during medical documentation tasks. Retrospective analysis of clinical documentation completed by hand or electronically.
Setting: Eleven bed pediatric intensive care unit within an academic medical center.
Participants: Five pediatric intensive care medicine attending physicians.
Measurements: Compared handwritten and electronic documentation to determine: (1) time spent entering data or composing notes; (2) number of descriptors documenting patients' physical exams; (3) users' preferences for structured or unstructured data entry; (4) frequency of documenting specific data elements related to nutritional support.
Results: Documentation time varied by user but not charting method: it took 13 % less time to document using the ECIS but this was not significant. Electronic documents were more detailed than handwritten containing 50 % more descriptors (17.8 ± 1.4 vs 11.6 ± 1.4) overall and some data elements that were not handwritten: information related to nutritional supplementation was recorded in 13 % of electronic documents but in none of 89 handwritten documents.
Conclusions: Electronic and handwritten documentation consumed equal amounts of time. Structured entry, compared to handwriting, may encourage recording of specific or otherwise unincorporated data elements resulting in a more detailed record. This suggests that user interfaces and decision support components may influence both the types and complexity of clinical data recorded by caregivers.

Key words User-computer interface · Hospital information systems · Task performance and analysis · Time and motion studies

Introduction

The intensive care unit is a complex environment where daily workflow requires integrating data from multiple sources, rapid interpretation and action based on that data, and generation of reports to multiple data users. Electronic clinical information systems (ECIS) potentially increase efficiency of data management by reducing duplication of effort [1], enhancing legibility [2, 3, 4, 5], enhancing data completeness and correctness [5, 6], and facilitating recall of related data (e.g., patients with similar diagnoses or medical problems) that is central to correlating the process of care with clinical outcomes. It is possible, however, that these potential benefits are balanced or outweighed by other effects such as an increase in time or the perception that the system is complex to use. Some caregivers are reluctant to use ECIS because of perceived increases in time and effort compared to established procedures such as handwriting. Indeed, acceptance is more likely when the electronic system provides direct benefit to caregivers [7] particularly if that benefit is time and effort saved [8].

It is not completely known how ECIS affect caregiver's workflow and time expenditure, or whether they influence the quantity or quality of data recorded. Several studies have found that ECIS reduce nursing documentation times [9, 10, 11] although these reductions have not uniformly increased time on patient care. The effects of ECIS on physician workflow is harder to assess as there have been few studies examining the impact on physician's time [12]. One study reported increases in physician documentation time [13] although this study used self-reported assessments of time expenditure.

We hypothesized that integrating physicians' information processing tasks using an ECIS decreases time to complete these tasks by hand. We further hypothesized that structured data entry encourages generation of more detailed records and capture of specific data elements even when entry is voluntary. Accordingly, we compared data capture by handwriting to capture and processing using a novel ECIS developed for our intensive care unit. The system stores structured and unstructured data entered on palmtop or desktop devices, allows recall of related data, and generates physician notes, reports of billable services and communication with outside physicians. We assessed the impact of electronic information processing on caregiver time expenditure and on the level of detail recorded in medical documentation. We also assessed the perceived value of electronic correspondence to caregivers besides primary users of the system.

Materials and methods

Background

Prior to implementing the ECIS, our group of five pediatric intensivists and several trainees shared responsibility for a set of non-integrated, handwritten information processing tasks. Intensivists wrote daily notes and recorded levels of service and time in attendance of each patient within a separate paper record that was reviewed daily by a clerical assistant and used to generate CPT codes for billing. Fellows and attendings also completed paper data entry forms that were collected by a second assistant who transcribed data from the paper forms to a computerized database. The data recorded in this database included patients' demographics and diagnoses, procedures performed in the ICU, events occurring as consequences of care (e.g., catheter-related thromboses and infections), and certain medications that were administered.

The setting for this study was an 11-bed multidisciplinary pediatric intensive care unit in an academic medical center. The unit accommodates approximately 800 admissions per year and 250 ground transports per year. It is staffed by five full-time pediatric intensivists who supervise the care of all patients. The population includes patients with multiple trauma, respiratory failure, congenital heart disease (before and after surgical repair), and following neurosurgical, orthopedic, and other surgical procedures. The study was completed over a period of 1 year.

Database development

Development environment

CLINFOSYS was developed using Microsoft Visual Basic for Applications and a Microsoft Jet (Access 97) database (Microsoft, Redmond, Wash., USA). CLINFOSYS accepts structured and/or unstructured data entered by keyboard or palm-computing device (Fig. 1) and generates a series of outputs serving the primary functions of the system.[1] Data are stored using two different methods. Related data including demographics and descriptions of individual admissions (e.g., admission dates, discharge dates, origins, etc.) are stored in standard relational form. In order to provide more economical data storage, we used an entity-attribute-value (EAV) model to store the numerical and textual descriptors of the clinical encounters [14, 15]. In the EAV tables, the entity refers to the patient and each EAV triplet is time-stamped. An attribute-value pair could label and store a block of text data such as a 'History of Present Illness' or a single datum such as heart rate. We chose this method because any of more than 50 numeric and text descriptors could be used to describe an encounter and we sought to leave the range of descriptors flexible in order to enable future addition of other descriptors.[2]

Data entry/user interface

Records of new diagnoses, procedures, events, and medications are added by selecting the appropriate descriptor from tree-structured lists (Fig. 2) that are linked to standard coding (ICD-9,

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[1] Although data entry on the palmtop device is limited to free-text in patient-specific memos, a block of data can be identified by specific prefixes to allow automatic parsing into the appropriate structured data elements on the CLINFOSYS data entry screens. Macros were written for the palmtop device that encourage structured data entry for such data elements as ventilator settings, nutritional supplement formulations, vital signs, and laboratory values.

[2] The group of elements describing a single encounter are committed as a single transaction to prevent losing elements in the event that the storage failed midway. One difficulty with using the EAV model is in recording authorship of the data entered for each clinical encounter. We store the author identifier as an entity attribute value triplet stamped with the identical date and time of the remaining data describing the encounter. We also store an additional EAV triplet describing a unique identification number that allows records pertaining to the same hospital admission (hospital admission identification number) to be related to each other. The approach of incorporating the authorship and hospital admission identification number in each EAV set allows us to extract specific encounters recorded by specific authors. This requires establishing a set of "self join" relationships where the joined fields are the patient identifier and the date/time the data were recorded.

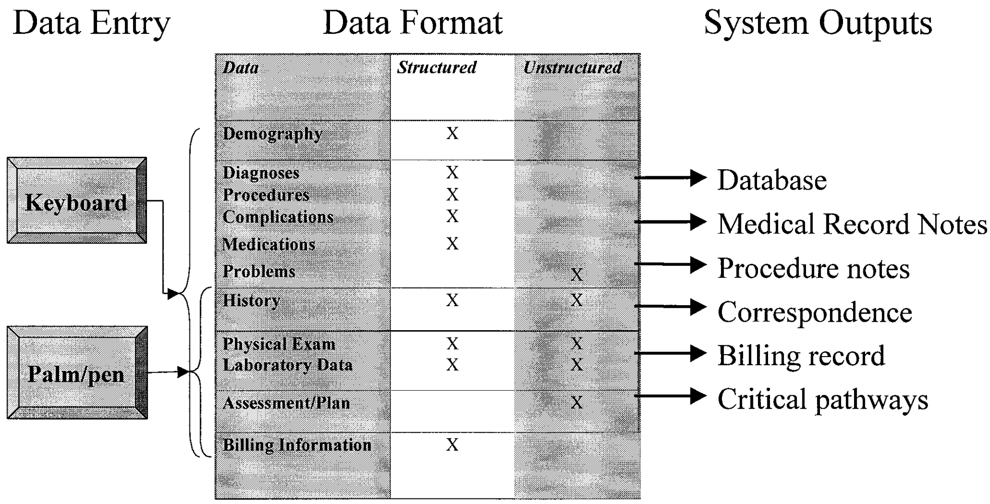


Fig. 1 Schema of data flow and data format (i.e., structured vs unstructured) for CLINFOSYS. Data is entered via the keyboard of a desktop computer or by pen entry onto a palm-computing device. Both data entry methods allow structured and unstructured (i.e., free text) data entry, but the palm device allows entry into only a subset of database tables. Multiple outputs are generated by the system for integration into the medical record, to facilitate communication with other caregivers, and for administrative functions such as billing

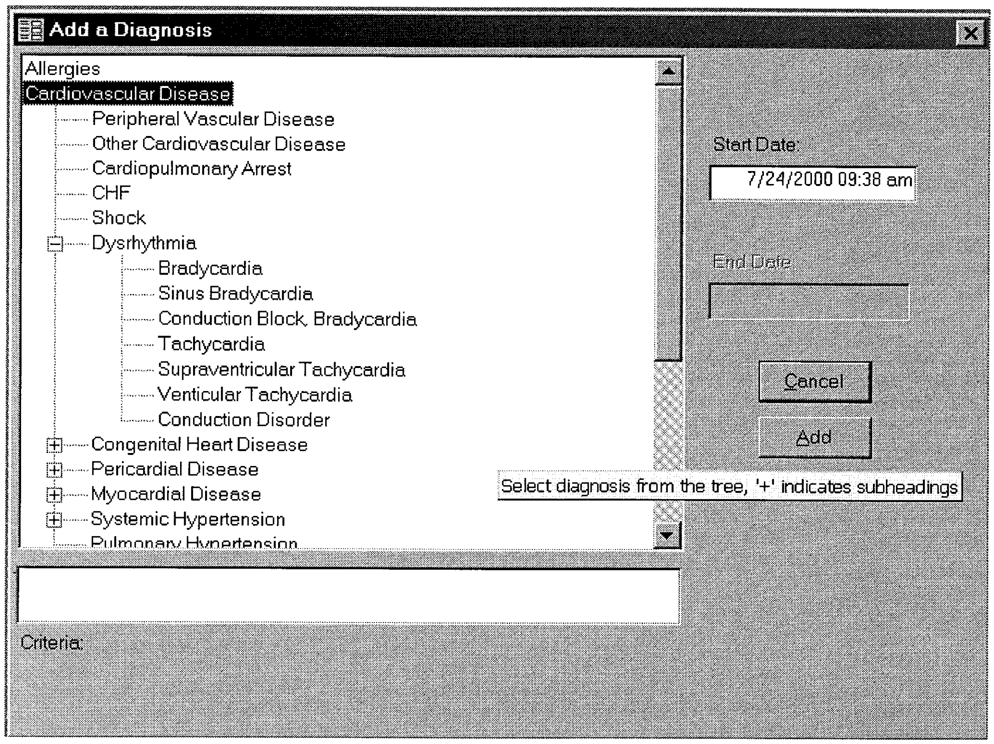


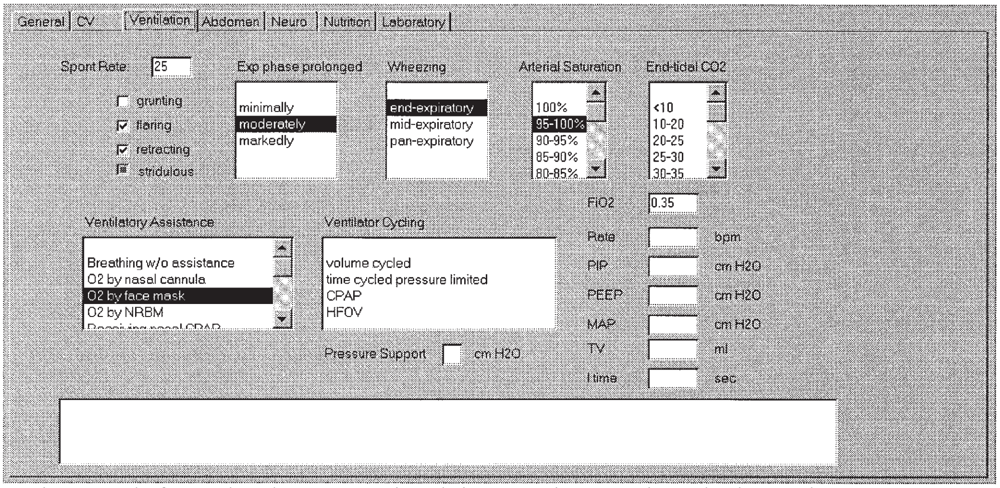
Fig. 2 CLINFOSYS data entry screen for selecting diagnoses from a tree structured list. Diagnoses are organized by the organ systems affected. Navigation proceeds from general (i.e., organ systems affected) to more specific (disease category, subcategory). The most specific disease entity is selected and the date the diagnosis was made is recorded. Similar lists are used to record procedures, laboratory data, complications, and medications

CPT-4) systems. Unstructured data are recorded as free-text entries. Some structure is imparted to these free-text entries by distributing the content among specific text boxes. For example, the physical exam may be described by a single multi-sentence entry into one of the text boxes provided on the form, or may be distributed by physiological systems (e.g., cardiovascular, respiratory) or a combination of both. This provides a great deal of flexibility in that the caregiver may describe an encounter by entry of free-text into a single text box or may elect to describe any of more than 50 structured variables. Those structured variables that describe the physical exam are limited to vital signs and core critical care systems (respiratory, cardiovascular, neurological, and gastrointestinal). The default value for each data entry object is 'null' and values are assigned based on the caregivers' interactions. Only those elements that have an assigned value (i.e., that the caregiver interacted with) are recorded to the database.

Natural language generation

After describing a clinical encounter, the caregiver generates a printed record of the encounter for incorporation into the paper medical record. Rendering understandable and acceptable text output from the EAV values presents a series of challenges [16] in

Fig. 3 Natural language generation from structured data entry. *Top panel* illustrates the CLINFOSYS data entry screen for recording respiratory and ventilation parameters. Data entry objects that do not contain a value are not incorporated into the natural language output or the clinical database. The text illustrates the results of natural language generation based on the interactions with the data entry objects in the *top panel*



Respiratory: O2 by face mask. 25 bpm. Not grunting. Flaring. Retracting. Appreciate endexpiratory wheezes. Expiratory phase moderately prolonged. The arterial oxygen saturation is 95–100%. FiO2: 0.35.

developing both the strings describing each data element and the overall structure of the document. The natural language string for each element is constructed by concatenation of a prefix, value, and suffix. The values are derived from the values in the data entry text boxes (when applicable), from the text selected in list or combo boxes, or from the data entry object labels on the data entry form (Fig. 3).[3] The strings that result from the natural language generation are transferred automatically to a document template in Microsoft Word 97 (Microsoft, Redmond, Wash., USA) which is printed for incorporation into the paper chart.

Decision support

CLINFOSYS calculates calories provided by nutritional supplementation and displays growth trajectories on standard sex-appropriate growth curves. The calculations rely on entry of data related to the formulations of parenteral and enteral supplements as well as the rates of their delivery.

Outputs

The primary intent of the system was to generate notes for the medical record including admission history and physical exam records, daily progress notes, and procedure notes. Besides daily documentation, the system also generates clinical summaries to serve the purpose of chart review or communication with other medical personnel. It also generates a number of administrative reports including summaries of clinical activity.[4]

[3] Structure is provided to the document by ordering data presentation as specified in a table ordering all possible data entry objects and providing formatting information.

[4] Such as monthly admission rates, mean daily census information, numbers of patients transported by our ground transport service and reports of diagnosis-specific length of stay and mortality or morbidity data.

Assessment

Implementation and training

Each of the caregivers that interacted with the system was provided a 30–45 min orientation and demonstration. Each user already had some familiarity with the concept of graphical user interfaces and one or more components of the applications integrated in this system. No specific guidance was provided with respect to how a clinical encounter would be described (i.e., which data entry objects were to be utilized). Initially, electronic charting of patient encounters was optional. However, electronic charting became the preferred method of documentation for each user by the end of their first week of use.[5]

Time

We assessed the impact of CLINFOSYS on the time involved in the following tasks: generating admission and progress notes and completing data entry for databases of clinical activity and billable services. Data were derived by work sampling [17, 18] where one of the authors (P.S.) monitored the process using a stopwatch. For electronic data capture, the total time spent documenting all three types of information was recorded as a single value because it was not possible to separate the tasks into independent components. For handwritten data capture, the time documenting the patient encounter was recorded as was the combined time for entering data into the billing record and clinical activity database. These two data entry tasks were considered together because the two data entry forms were located in the same physical location and were completed consecutively. Observations were conducted on weekdays over a one-week period for each user. During that one-week period, electronic and handwritten documentation was performed on alternate days. This phase of the study was completed

[5] Although one of the novel features of CLINFOSYS is the implementation of a device-independent interface to the palmtop device, the use of palmtop computers has not been as readily accepted as the system overall. Only the developer has repeatedly used the palmtop computer for remote data entry.

one year after implementing CLINFOSYS and all users were considered fully trained in its operation.

Level of detail of the record: describing the physical exam and recording objective data

We assessed the level of detail in electronic and handwritten encounter records by counting the number of individual descriptors used to document the patients' physical examinations. We chose to examine the physical exam component of the record because it represents the segment with the greatest potential for encouraged structure in the electronic documents. In contrast, information related to historical information or the caregiver's assessment and plan are generated by unstructured data entry in both the electronic and handwritten records. Moreover, the physical exam component may be easily separated into its basic elements and the number of those elements can be easily quantified.

Structured data entry offers the possibility of prompting or encouraging entry of specific data elements. This may be particularly noticeable for data elements that are recorded with low frequency in the handwritten record. This effect may also be amplified if the user derives direct value from the data entry task. To determine if structured data entry increased the documentation of specific data elements, we examined the frequency with which users documented, in electronic and handwritten formats, the formulations for nutritional supplements (enteral and/or parenteral) that were being provided to patients. We chose to examine data related to nutritional supplementation because it is not necessarily a required element in daily documentation and because CLINFOSYS provided added value to the data entry task by automating the calculations of the number of calories provided directly from the nutrition formulations. The nutrition-related data collected by CLINFOSYS included: rates of intravenous and enteral nutrition; carbohydrate, protein, fat, and electrolyte composition of intravenous nutrition; caloric density of enteral formulas; and, administration of enteral additives.

Perceived value of electronic correspondence to non-users

In order to assess the impact of the electronic system on non-users, we surveyed referring physicians to characterize the value of electronic correspondence that are generated at the time of documentation by the system's users. These correspondences consisted of history and/or progress notes, or summaries of the hospitalization that were faxed to patients' primary care providers. The correspondences were accompanied by a survey asking the providers to rate the usefulness of the correspondence using a Likert scale with a range of 1 (not useful) to 5 (very useful).[6]

Statistical analysis

Statistical analysis was performed using the Minitab (Minitab, State College, Penn., USA) software package. We examined the influence of caregiver and charting style (i.e., using CLINFOSYS vs handwriting) on time expenditures and the level of detail within documents by multivariate analysis of variance using a general linear model. We compared the frequency of specific data elements in the electronic and handwritten documentation using the Z-test of proportions with a P-value < 0.05 considered significant.

This study was carried out with the approval of our Institutional Review Board. The board waived the need for informed consent for this study.

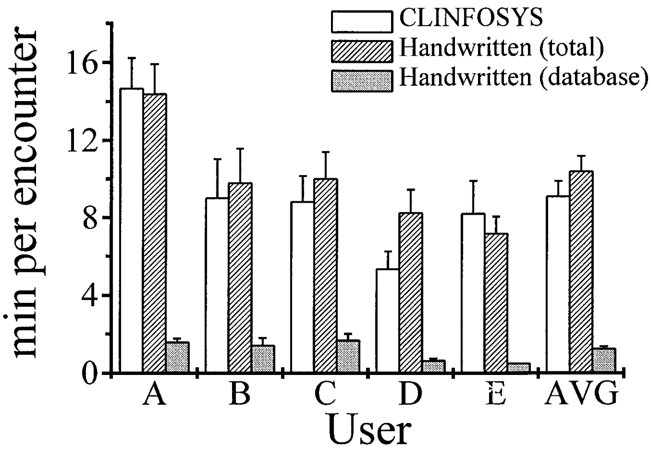


Fig. 4 Comparison of the time spent documenting an encounter by each user using CLINFOSYS or by handwriting. The total time spent handwriting and the time spent on handwritten data entry into the billing and clinical activity databases are shown. Values are the mean ± SEM. User D is the CLINFOSYS developer/author

Results

Impact of workflow and time expenditures

We analyzed the main effects of caregiver and charting style (i.e., CLINFOSYS vs handwritten) on the dependent variable, time. Overall, the time spent documenting using CLINFOSYS was not significantly different ($P > 0.3$) from handwriting although the average times spent documenting an encounter varied significantly ($P < 0.01$) among caregivers (Fig. 4). On average, it took 68 s less time (13 %) to document an encounter using CLINFOSYS than to write a note and record information for billing and the clinical activity database. This difference was not significant. When handwriting, recording information for billing and the clinical activity database consumed 72 s per encounter. This excludes time for transfer from handwritten data-entry forms to the database because we wished to compare time expenditures by caregivers only and a clerical assistant accomplished that particular task.

We considered the possibility that it took longer to enter data or compose a note electronically when the system was first implemented compared to the period

[6] We evaluated caregiver preference for structured compared to unstructured data entry by estimating the average number of data entry objects on the graphical user interface that were used to document a patient encounter electronically. A minimum of one object, recording the entire encounter in free text, was used to document each encounter.

of the time analysis above. In order to determine the presence and duration of this type of training effect, we extracted the times at which each electronic document was completed. Because sets of daily notes are often completed consecutively in a single session at the computer, the time between consecutive notes represents the minimum time spent documenting each encounter. We reasoned that, as the user grew more familiar with electronic documentation, they would generate documents in shorter periods of time. Accordingly, we used multivariate ANOVA to examine main effects of user and time (in months) since implementation on the percentage of notes written within 10 min of the prior note. Notes written on single calendar days by a single user were grouped and the interval between notes was determined for each consecutive pair.[7]

We found that the fraction of notes written within 10 min varied widely from month to month and from user to user. Analysis of the entire period of use revealed main effects of time ($P < 0.01$) and user ($P < 0.01$). Specifically, the percentage of notes written within 10 min increased until 2 months after the system was implemented. After that there was no additional training effect (i.e., no variation with time). The 2-month training period corresponds to each user having had approximately 2 weeks of experience composing notes electronically.

Impact on the level of detail in documentation

The notes recorded during the observation period were assessed for the level of detail by counting the number of descriptors documenting the physical exam (Fig. 5). Overall, the mean number of descriptors was 17.8 (± 1.4) for electronic documents and 11.6 (± 1.4) for handwritten documents. Thus, electronic documents contained 50 % more descriptors than handwritten records. Multivariate ANOVA revealed significant main effects of both user ($P < 0.01$) and charting method ($P < 0.01$).

Examination of 4006 separate encounters documented using CLINFOSYS revealed inclusion of nutrition formulations in 13 % although the frequency varied by user from 3 % (User C) to 26 % (User B). Based on a power analysis, we estimated that analysis of 80 handwritten documents would provide 80 % power in discerning a 60 % reduction in the frequency with which

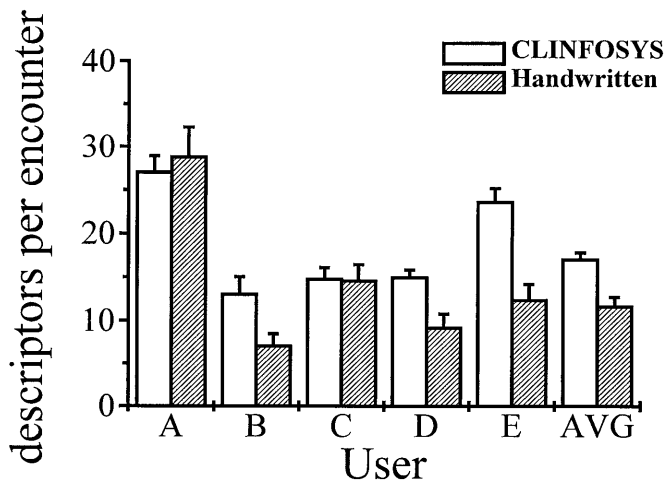


Fig. 5 Level of detail in electronic and handwritten documentation. The mean (± SEM) number of descriptors used to describe the physical exam documented in each encounter is shown for each user. For three users (Users B, D, and E), there were significantly more descriptors used when documenting electronically (Student's unpaired *t*-test; $P < 0.05$). User D is the CLINFOSYS developer/author

nutrition formulations were included in the handwritten documents ($\alpha = 0.05$). Examination of 35 handwritten documents generated during the workflow analysis and 54 handwritten documents generated on ten randomly selected dates from the calendar year prior to CLINFOSYS implementation, revealed that nutritional formulations were not recorded in handwritten document. This difference in the proportion of documents describing nutritional supplementation was highly significant with a 95 % confidence interval for the difference in proportions of 0.12–0.14 ($P < 0.001$).

There is significant variability in the degree to which various individuals employ structured versus non-structured data entry. Whereas each caregiver used an average of 12–25 structured elements and four to seven non-structured data entry objects to describe a single encounter, with time, two users began to describe encounters with fewer elements, relying predominately on unstructured elements (Fig. 6). One of the users has largely abandoned the use of structured data entry in favor of writing single free-text descriptions of historical, exam, and assessment/plan data. A second user structures their documentation without interacting with individual data entry objects by generating a text template incorporating approximately 25 elements and using the template for subsequent documents. These alterations in charting style did not occur within the first 6 months after implementation of CLINFOSYS. Examination of the average number of elements used per encounter revealed a modest decline with time (~ 1 element per note per month; $r = 0.94$).

[7] At times (primarily nighttime) when one physician is providing care on behalf of another in the group, notes are more likely to be composed close to the time that each episode of care is delivered rather than consecutively during a single episode of electronic documentation. To reduce the influence of note-writing that occurs outside of the normal daily workflow, data for an individual user was omitted for months in which that user wrote less than 10 notes.

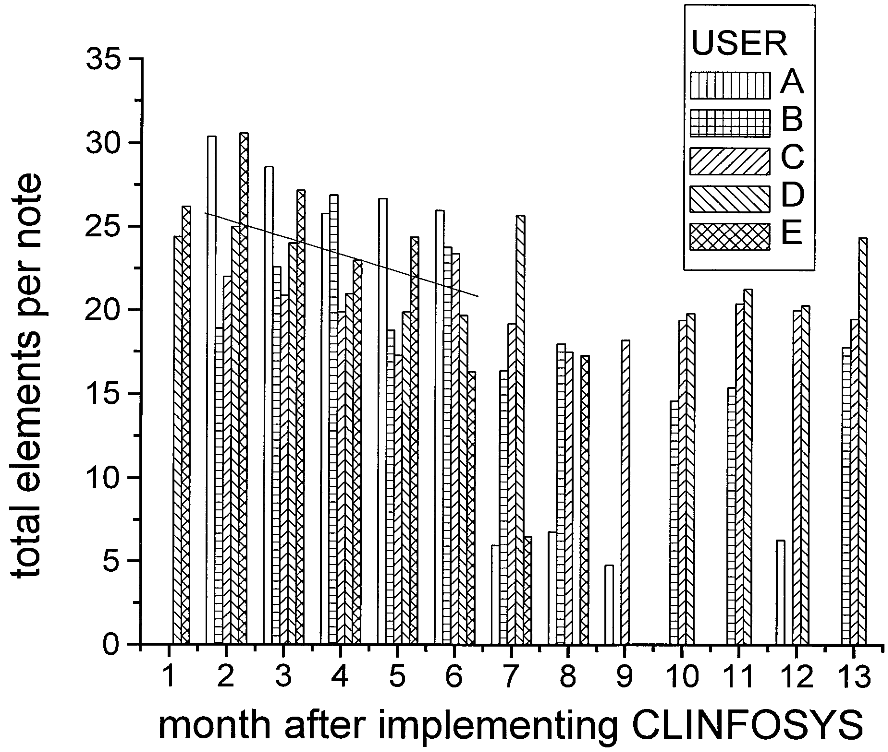


Fig. 6 Changes in the use of structured data entry with time. The average number of elements used to document encounters by each user are shown as a function of time since implementation of CLINFOSYS. Discontinuities in each line reflect months when a given user had no patient contact and therefore no opportunity to document. Linear regression was performed for the average number of elements among users over the time period from month 2 (by which time all users were using the system) and month 6 (after which users A and E altered their pattern of use). The best fit is shown by the dotted line

Impact of the system on non-users

Although a limited number of people interact directly with CLINFOSYS (users), a larger number rely on the information provided. One group of beneficiaries are primary physicians who refer patients to the ICU. Correspondences to this group were aimed at improving the quality of communication and providing records of their patients' hospitalizations.[8] We evaluated the primary physicians responses to the first such correspondence they received electronically. Approximately 40 % (19/47) of physicians responded to the first survey accompanying the original correspondence. Second surveys were sent by facsimile to those failing to respond. Overall, 67 % responded (32/47) and these responders judged the correspondences to be very useful with a mean score of 4.7 (range 3–5; SEM 0.1). Other benefits of electronic information processing derive from the readability of the documentation [5].

Discussion

The CLINFOSYS prototype integrates tasks previously completed independently: daily medical note writing, data entry to databases of billable services provided and clinical activity, and correspondence. The value of integration, however, depends on timesaving [8] and on the added value of the products of this activity [7]. Although we were not able to demonstrate significant timesavings with CLINFOSYS, it is important that electronic entry did not take any additional time than handwriting. These results are consistent with those of others that have measured the impact of ECIS in the ambulatory care setting [19]. For some tasks, electronic data entry has been more rapid than handwriting [1]. The lack of timesavings for caregivers in this study could result from greater complexity in documentation compared to that in other studies or from differences in user interfaces.

It is possible that electronic data entry took more time than handwriting when users first began documenting electronically. Although intervals between successive notes are not direct measures of actual time spent entering data and composing a note, they do provide upper limits.[9] We found that once each user had used the

[8] Correspondences were typically sent on admission of the patient to the intensive care unit, again at discharge, and at sporadic intervals during lengthy hospitalizations.

[9] Clearly, many factors influence the times including individual user work habits, the number of distractions, as well as the complexity of documentation. Given that each user had the habit of writing some daily notes consecutively, it is reasonable to assume, if work habits didn't change over time, that the more complex the method of documentation, the less frequent notes could be completed in short periods after the prior notes.

system for ~2 weeks, there was no further increase in the percentage of notes written within 10 min, implying familiarity and efficiency in interacting with CLINFOSYS became stable by the end of that brief training period.[10]

Each user gradually developed preferences regarding the use of structured and unstructured data entry. At least three factors may have influenced the decision to use one or the other method. First, users may have perceived a timesavings advantage of one method or the other. Second, users may not have been satisfied with the set of specific attributes described or the natural language generated by structured entry.[11] A third factor that may have influenced the use of structured and unstructured data entry was the novelty of the electronic system that may have produced a period of exploring the system's features.

The option of unstructured data entry and the lack of obligatory data entry may increase user acceptance owing to flexibility of data entry [7] at the cost of increasing the challenge of data extraction and analysis because multiple data objects need be searched to identify particular attributes. One approach to enhancing structure would be to make some entry into specific data objects obligatory although this may diminish user acceptance by increasing the time necessary to complete data entry [7, 20].

One limitation in this study is in assessing the quality of the electronic and handwritten documents. Part of this difficulty is inherent in analyzing documents that serve multiple functions to multiple subscribers. The medical record serves not only as a window into the assessments and plans of the individuals caring for patients, but also as a series of snapshots into the patient's state at particular instances in time. The record also serves as documentation of an individual's extent of participation in the care process.

A central question then, is what data adds value to that record. We chose to use the number of data elements (i.e., attributes, not words) as a measure of a document's level of detail for the following reasons: (1) We believe that while brevity is laudable, it is reasonable to assume that additional descriptors of components of the physical exam add relevant information, whether the findings are normal or abnormal, as long as those components are not viewed as perfunctory. In CLINFOSYS, structured data entry was limited to vital signs and core critical care systems including respiratory, cardiovascular, neurological, and gastrointestinal systems. There are no structured objects to facilitate recording of data that would be expected to be less useful for documentation within an ICU; (2) There were no required data entry fields. Therefore, an individual's decision to record a specific datum likely reflects their judgement that the data element either helps frame their thought process, documents an important patient attribute at that moment in time, or would have some value to future readers of the chart including other caregivers or auditors.

We found that providing the opportunity for structured data entry resulted in the more frequent inclusion of some data elements in the medical record. Specifically, data related to nutritional supplementation was electronically recorded frequently but not recorded in handwritten documents. It is interesting that this occurred even for the user (User A) who largely abandoned other structured data entry. We speculate that this resulted from the value added by automating calculations of nutritional support and suggest that providing decision support tools such as the nutrition calculator may encourage data entry.

In addition to the clinician users, other beneficiaries such as administrators or colleagues derive value from increased legibility, more detailed content, and the ability to generate administrative and patient-care reports. Although there may be a reporting bias weighted towards reports from satisfied data recipients, referring physicians overwhelmingly reported the electronic correspondence to be useful.

It is difficult to explicitly analyze the cost-benefit ratio of implementing CLINFOSYS. The system reduces labor costs by eliminating the time necessary to transcribe handwritten data entry forms to our computerized database (~ 0.1 FTE). We might decrease labor further if we eliminate duplicated data entry by integration with other institutional databases thereby distributing responsibility for data entry among different individuals.

A number of drivers make the adoption of electronic systems increasingly attractive. For example, quality management necessitates the ability to examine the relationship between the process of care and clinical outcomes on populations of patients. This process involves either parallel entry of data into handwritten records and databases or distribution of data to multiple users (i.e., the medical record and the quality management effort) from a common repository. Although the later approach is more efficient from the standpoint of the overall medical enterprise, it has the risk of increasing the burden on caregivers if it makes their own information processing tasks less efficient. Information systems may also be used to enhance quality by providing decision support. This may take the form of graphical displays to simplify detection and analysis of trends, calculators, and searchable databases to facilitate examination of the patient's linear record.

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[10] Alternatively, advances in natural language processing may facilitate data extraction from the unstructured text.

[11] We sought to minimize this possibility by deriving the specific text strings used in the natural language generation as well as the available data entry objects from group discussions at the inception of this project.

Despite these drivers, such systems have not yet been widely adopted. The reasons for this failure are certainly complex and varied. Explanations likely include financial consideration such as the difficulty in estimating the potential financial benefits derived through enhanced quality management activities and reduced medical-legal liability. A second set of factors, however, are personnel-related considerations such as uncertainty as to how such systems will impact staff workflow and the difficulties inherent in bringing about changes in the process of patient care and documentation. The later, may in part reflect a preconception that the ECIS will have a negative impact on time expenditure. We have shown that it is possible to enhance physician efficiency and improve the quality of data capture by integrating a series of tasks into a single activity.

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