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How to Use Data Analysis from Clinical Information Systems to Help Manage Intensive Care Units

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Secondary analysis of patient-related data from clinical information systems offers potential for ICU management support, quality and cost improvements. Dr. Imhoff discusses processes and examples of Clinical Information System (CIS) data analysis.

Introduction

Clinical Information Systems (CIS) facilitate the acquisition of patient-related data in electronic format with little or no extra clinical work. While electronic medical documentation at the point of care can improve clinical workflows, the cross-sectional or longitudinal analysis of patient-related data from CIS on a patient, departmental, or hospital basis can provide information to help manage intensive care units. This secondary data analysis aims at cost reductions, quality improvements and quality control, coding and charge capture and scientific research. This article will give an overview of the processes of data analysis, present some clinical examples, and conclude with a discussion of the value of secondary data analysis.

The Process of Data Analysis

The process of data analysis includes data acquisition, transfer, filtering and extraction, quality control, presentation and, finally, analysis.

When planning data acquisition, both primary and secondary data analysis needs should be taken into account. Only 5-10% of all variables in a CIS are acquired automatically. These variables are gathered from bedside devices, e.g. physiologic monitors, ventilators, and IV devices. Additional data are interfaced from the hospital information system (HIS), the laboratory information system (LIS) or other information systems. Although automated data account for only a relatively small number of variables, they can, depending on the sampling rate, generate large amounts of data. Nevertheless, most patient-related data are acquired directly at the bedside, where most variables are entered by hand. It appears very unlikely that the entry of variables such as clinical observations, nursing procedures, therapeutic measures, medications or doctor's orders can be automated in the foreseeable future.

All data collected must be structured, so that they can be subjected to statistical analysis. Numeric or alpha-numeric data (e.g. vital signs, fluid balance and medication administration) are directly accessible for most statistical applications. Free text data, which traditionally makes up large portions of medical documentation (e.g. physician's or nursing notes), cannot be easily analyzed with statistical methods. Therefore, free text entries into a CIS should be avoided wherever possible. For instance, clinical observations or interventions should be documented in a strictly structured fashion, coding terms with selection lists and menu items. This structured qualitative data can, in contrast to free text information, be exported directly for statistical analysis. Highly structured data acquisition provides the best basis for successful data analysis.

Quality, accuracy and reliability of all data are initially determined at data entry. Quality assurance measures should include plausibility checks at data entry or data transfer, selection lists or menu items (as mentioned above) and automated reminders for required data fields. Moreover, data need to be acquired and entered in a timely fashion. All data must be time stamped, both for the time when the data were acquired and for the time when the data were entered into the system.

Prior to initiating data analysis, it is advisable to export data from the clinical database to a secondary database (Ledbetter and Morgan 2001; Mill and Staggers 1994). This is especially important, because the primary clinical database represents the medicallegal patient record, and because complex queries against the primary database may compromise bedside performance of the CIS. During this export process, data can also be filtered and de-identified, if needed.

Clinical Examples

A few examples show how analysis of CIS data can help to manage ICUs. The analyses discussed were done on data from a 16-bed surgical ICU in a tertiary referral centre in Germany. A commercially available CIS was installed in the ICU in 1992. All data used for the analyses were acquired as part of the standard clinical documentation done with the CIS. Before using data for clinically and management relevant analyses, the accuracy of the data was verified.

In one study, medication documentation from 3,537 consecutive treatment days was compared to pharmacy records. Medication volume showed a difference of less than 5% to the phar-macy records. This difference was attributable to inevitable loss during drug preparation, only partially used packages and damaged deliveries. It was constant over time and across medication groups. Precision of documentation was checked in random samples and showed a very close correlation between medication documentation, doctor's orders, and pharmacy records. Therefore, the medication documentation in the CIS appeared sufficiently precise for further cost evaluation (Imhoff 1997).

In another study for selected drugs and infusions, the precision of dose documentation and the relation in time between charted dose and effect on online hemodynamic variables was evaluated applying time series analysis of these variables. The analysis of a total of 34,604 time series with 5,264 catecholamine or fluid interventions revealed an average time difference between intervention as charted and calculated hemodynamic effect was 12.34 minutes (0 - 29 min) (Imhoff et al 1999). Such time lags may affect automated decision support, but rarely affect management- related data analysis.

After establishing adequate precision and completeness of CIS data, post hoc data analysis was used to support ICU management. Such data analyses can be a single analysis for a specific question run once, or an automated analysis run repeatedly:

Charge Capture and Calculation of Reimbursement Codes: Most intensive care related International Classification Procedures in Medicine (ICPM) codes and the majority of intensive care International Classification of Diseases (ICD) codes, as well as other charge codes, can be generated from the CIS database without additional workload (Coleman et al. 1997; Dexter et al. 1998; Grewal and Reed 1994). Examples include the inference of codes for renal replacement therapy from the fluid balance data, or complex intensive care codes from Simplified Acute Physiology Score (SAPS) and Therapeutic Intervention Scoring System (TISS) scores, as required in the German Disease Related Groups (DRG) reimbursement system. Even if some codes cannot be calculated and physician supervision is still recommended, this process can save more than 80% of the coding time for physicians and markedly improves the DRG coding quality (Imhoff 2004).

Nursing Scoring:

In a prospective study with 602 consecutive ICU patients, TISS-76 calculated from the CIS database was compared to TISS-76 done manually. It showed that manual scoring underestimated the actual TISS by at least 20%([Imhoff 1997).

Cost Control:

Over two years, duration of antibiotic application was calculated, and outliers were identified on a patientby– patient basis. For the first four quarters of the analysis, mean duration was 7.1 days, but outliers were between 35 and 69 days. After identifying this discrepancy and re-educating the residents, occurrence of antibiotic treatment for more than 21 days with the same drug was significantly reduced. The average antibiotic cost per treatment day decreased by 38% (Imhoff 1998).

Quality Control:

In 105 patients scheduled for extensive visceral surgery, data analysis determined how many patients did actually reach the therapeutic goals of a hemodynamic protocol and what therapeutic effort was necessary. After 12 hours in the ICU, 94 patients (89.5%) had reached the therapeutic goals. The CIS medication and fluid balance data showed that only very moderate therapeutic interventions were necessary on the average (Imhoff et al. 1998). This information could be used to inform management decisions regarding the therapeutic interventions employed in the ICU.

Discussion and Conclusions

Clinical documentation alone does not justify the cost and effort for a CIS or an electronic patient record and often cannot provide adequate return on investment in financial terms (Imhoff 2001). But the electronic capture of all patient-related data opens a potential for data analysis and management support that cannot be realized with traditional documentation tools, as shown in the examples above. CIS is also an invaluable tool to capture data for prospective clinical studies. In conjunction with decision support tools, such as computerized, rule-based treatment protocols, CIS can provide a platform for standardized single- and multi-center studies (East et al. 1999; Morris 1999).

The use of CIS data for secondary data analysis offers several undisputable advantages in comparison to paper-based documentation tools:

• Data must be entered only once.

- Detailed analyses beyond the scope of handwritten documentation are easily feasible.
- Detailed analyses facilitate strategic decision making.
- Analysis of CIS data also allows for control of processes, including the continuous validation of clinical protocols and pathways.

With secondary data analysis and ICU management support, CIS can show significant return on investment, both in medical and financial terms. But these benefits can only be realized if data capture, transfer and filtering are meticulously planned from the very beginning, data quality is maintained at a high level and data analyses are designed in a way that they really answer the questions of interest to ICU managers.

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