Enhancement of Clinician Workflow With Computer Order Entry

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Physician-operated order entry systems can bring great benefits to an institution. Such systems can improve the consistency, accuracy, safety, and cost-effectiveness of orders. When building or selecting order entry for an institution, consideration must be given to the many different scenarios in which orders are written and communicated. Transfer, post-op, pre-admission and discharge orders have different communication requirements from standard inpatient orders. In certain services, orders from a very limited set (such as warfarin orders) must be written frequently for a large number of patients. Intensive-care patients, chemotherapy patients, and others have particular requirements for ordering. A computerized order entry system should respond to these requirements in order to promote correct and efficient ordering. We present a number of these issues, their specific requirements, and the approach we have taken to ensure that the system both supports and enhances workflow.

INTRODUCTION

Computerized inpatient order entry (OE) systems have great potential to improve quality and cost-efficiency of care. Along with procedures and operations, orders are the means by which a physician's ideas about a patient's medical condition are translated into actions to be taken to improve that condition. If the physician uses the computer to enter orders, the computer can present relevant clinical information to the physician, guide doses, suggest alternatives, point out redundant orders, and warn when an order may not be compatible with a patient's conditions and other orders. By using these techniques, an intelligent OE system can prevent adverse events, reduce costs, and promote optimal care.[1,2]

When hospital information systems leaders first begin to design an order entry system, or to evaluate one for purchase, they are likely to think first of "standard" ordering -- streams of single orders entered for a single patient who is in a bed on an inpatient floor. In fact, many orders do not fall under this simple category. A large number of orders are entered on patients who are in transit: these include transfer orders from one service to another, post-operative orders, pre-admission orders, and discharge orders. Because these order sessions often involve a comprehensive listing or re-listing of all orders, they can be quite large: at Brigham and Women's, these situations account for 4% of all OE sessions and 36% of all orders entered.

Each of these order scenarios includes specific expectations of how the orders will be communicated. For example, transfer orders are written in advance of the transfer, while the patient is still on the initial service, but are normally acknowledged by the nurse on the receiving service. Discharge orders need to be communicated to the patient, including medication schedules and instructions, and to any outpatient health care entities such as nursing homes and visiting nursing services.

Even in the absence of patient movement, there are many clinical scenarios in which "standard" order entry does not fully support efficient workflow. In our experience with OE we have encountered several examples:

1. Orthopedic patients on warfarin: warfarin is commonly prescribed as a prophylaxis against thrombosis in patients recovering from hip, knee, and other orthopedic surgeries. There may be dozens of patients requiring adjustment of dosage each day. Physicians need an efficient way to go through the service and write correct warfarin orders for each patient.

2. Intensive-care patients: orders are usually chosen from a limited set, such as ventilator settings, blood transfusions, and a small list of medications. The doctor enters the orders in many small sessions, usually while looking at a profile of the patient's current treatments and parameters.

There are many other examples, including chemotherapy and total parenteral nutrition. In these and other situations, users expect a complex collection of information to be at their fingertips, and

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need to be able to make complex orders easily and efficiently. An OE system should strive to provide, at the minimum, the same functionality and convenience that were present in the paper system. In most cases, the computer should be able to provide considerable additional value, such as automatic information gathering and reorganization, to support these scenarios.

In our OE system, we have built special software elements for situations such as these. We consider support for these situations to be required features of any complete OE system, essential for user acceptance and essential if the full benefits of OE are to be realized. We have established a number of standard models of clinical workflow that may be educational for others who are developing or purchasing clinical systems. We will discuss here a number of these situations, analyze their special requirements, and the approach we have taken to ensure that the system supports and enhances practice.

METHODS

Brigham and Women's Hospital (BWH) is a 720-bed tertiary care center affiliated with Harvard Medical School. BWH uses a comprehensive integrated computing system, BICS, originally based on the Beth Israel system[3] and developed independently at BWH since 1988[4]. BICS runs on an all-microcomputer platform based principally on Intel 486 computers, connected by a Token Ring network. There are 120 servers and 4000 clients serving the hospital and outlying practices.

The OE system was developed in the hospital and first implemented in May 1993; it is now used for all orders on adult inpatients[5,6]. Approximately 120,000 orders per week are entered in the system. The system contains numerous features to prevent adverse events and improve resource utilization, including allergy and interaction checks, renal-dose correction, associated (consequent) orders, order sets, redundant-order checks, and charge displays. About 80% of orders are entered by resident physicians; the others are entered by nurses (in response to voice orders), senior physicians, physician assistants, nurse midwives, and students.

SCENARIOS

Transfers And Post-Op Orders

When a patient is transferred from one service to another, or when a patient completes a surgical procedure, several special workflow elements occur:

1. The doctor reviews the existing orders. He may decide to D/C (stop) all prior orders and start with a clean slate. Alternatively, he may wish to continue all prior orders, or pick and choose which orders to retain. A very common scenario is to review medications and D/C all other orders.

2. The doctor enters the new transfer orders. Very often, the doctor uses a set predetermined for the situation, particularly post-operative orders for a given operation. Transfer orders also have stereotyped fields, such as service, diagnosis, condition. The doctor enters the set orders and any additional orders, then signs them.

3. Pre-transfer orders are still in effect until the transfer occurs. The nurse on the initial service may review the orders, but formal acknowledgment is performed by the nurse on the accepting service. If the patient is post-surgical and will be spending time in the recovery room, the nurses there perform the "initial service" function. They may actually execute some orders if the transfer is delayed, and will note this on the orders. In all cases, orders which are transmitted to ancillary areas, such as pharmacy, must be routed to the proper station for the situation.

4. When the patient reaches the accepting floor, the orders become standard, active orders for the nurse there.

5. If the transfer is delayed and conditions change, the doctor may modify the orders before the transfer occurs. Or, the doctor may write other orders which are meant to be acted upon while the patient is still on the initial service.

6. If circumstances change, the patient may not be transferred at all. In this case, the transfer orders are discarded.

Essentially, once a transfer order session is entered, there are two co-existing sets of orders for the patient: pre-transfer orders and post-transfer orders.

All intelligent functions, such as drug interaction checks, must act within the proper context.

The BICS OE system's transfer/post-op module is designed to handle these complex communication issues. When a physician chooses Enter Transfer Orders or Enter Post-Op Orders from the menu, the system first gives her options for continuing or D/C'ing prior orders, then brings up a list of the standard transfer or post-op templates available on BICS. She can choose one of these templates or the "Generic template" which has the basic fields, filled in with existing information where appropriate. Once the template and any additional orders are signed, the existence of transfer orders appears on the floor status monitor (Figure 1):

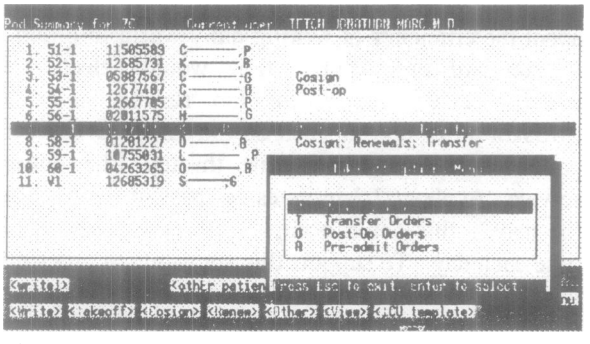

Figure 1. The floor monitor shows that patients #7 and #8 have transfer orders, while patient #4 has post-op orders. These patients have not yet been moved to the accepting floor. When the nurse goes to take off (acknowledge) orders on one of these patients, a window pops up to inquire whether to work with current (pre-transfer) orders or post-transfer orders.

If, before the patient is transferred, the nurse on the initial service wishes to work with the orders, the nurse can choose to take off (acknowledge) the orders in the usual fashion. BICS will ask whether the nurse wishes to work with pre-transfer or post-transfer orders. The nurse can view pre-transfer orders and annotate them if some are carried out. Similarly, if the doctor goes to enter more orders before the patient is transferred, BICS will ask whether the new entries apply to the pre-transfer orders, post-transfer orders, or both.

The transfer orders may be deleted entirely if the transfer is canceled. If the orders are not deleted, they will expire in twenty-four hours; before that time, the doctor is given the chance to extend the transfer orders for an additional day.

Pre-Admission Orders

Pre-admission orders may be written just before the patient is admitted, or may be written days or weeks before a scheduled admission. Workflow considerations include:

1. Pre-admission orders need to become active when the patient is admitted, but should be reviewed and cosigned if there is a significant interval between orders and the actual admission.
2. The orders should also be reviewed by the system for any new circumstances (new allergies, new lab results that interact with the orders) which have occurred in the interim.
3. If the admission is canceled, or if another admission intervenes before the scheduled one, the pre-admission orders should not be inadvertently accepted.

Based on these considerations, we have divided pre-admit orders into two functional types: orders for an admission the same day, and orders for an admission several days to weeks in the future. Same-day orders are automatically activated when the patient is officially admitted on BICS. Orders for longer time intervals must be reviewed and cosigned by the admitting physician when the patient arrives.

To help make this division, and to make sure that pre-admission sessions are not left around in the absence of an actual admission, BICS asks the orderer what the likely pre-admission interval will be. If this interval is exceeded without an actual admission taking place, the computer will notify the orderer (through electronic mail) that the pre-admission orders will expire unless they are renewed.

Discharge Orders

The essential workflow items for discharge orders at our hospital are as follows:

1. A brief discharge summary is completed by the physician. This includes medications, diet and therapy orders, follow-up appointments, return-to-work instructions, a summary of major diagnoses and procedures, and a brief summary of the hospital course.
2. The nurse completes additional discharge instructions, including more detail concerning

the medications and treatments, and information on home care or nursing care arrangements.

3. The nurse may provide the patient with a graphical schedule of medication doses for the patient's convenience.

4. Prescriptions are written and signed by the doctor.

5. A summary of the discharge medications and hospital course is sent to the patient's primary provider.

Sands[7] and others have found ways to automate some of this process, particularly the medications. In our case, because of the tight integration of BICS, much of the needed information above is already available on-line.

The doctor's discharge template (Figure 2) allows him to enter specific information, such as the time and date of discharge. The inpatient medications are brought up in a window; the doctor can choose which medications to continue for outpatient therapy, which to stop, and which to modify (for example, to convert an IV inpatient medication to oral form for outpatient use). If the patient's primary provider uses the BICS ambulatory record, that provider can selectively merge these medications with the existing outpatient medications, to keep the list up to date.

The discharge medications are also brought over to the nurse's instruction template, for more detailed explanation. In addition, a graphical chart of dosage times for discharge meds can be printed, and drug instructions (from the Medicom pharmacy database) can be printed in English or Spanish.

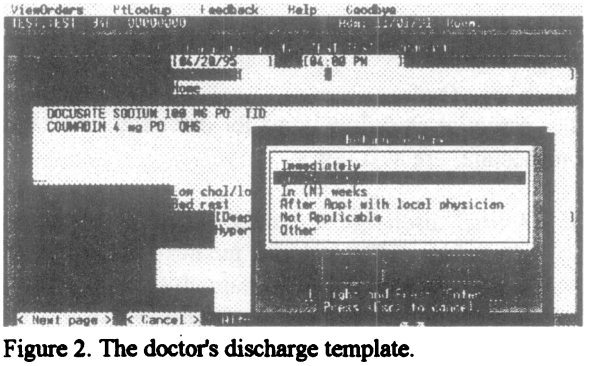

Figure 2. The doctor's discharge template.

The discharge template also allows the doctor to specify return-to-work conditions, and to list follow-up appointments. Appointments already scheduled in BICS will be automatically included. Diet and activity information are also filled in from OE. The brief hospital summary can be drawn directly from the ongoing summary produced by the Sign-Out system[8]. When completed, the doctor's orders and nurse's instructions are printed. These are also available for viewing on-line at any time in the future.

Prescription printing is being developed for BICS in 1995, along with exploration of electronic prescription transfer.

SPECIAL SITUATIONS

Warfarin spreadsheet

The orthopedic surgery physicians were concerned about the efficiency of writing daily warfarin orders. In standard order entry, they would select one patient, review the recent lab results, enter a warfarin order, sign it, then do the same for another patient, until they had gone through the entire service. At about 2-3 minutes per patient to do all of the above, this could occupy well over an hour of time each day. To support this very limited ordering function on a large range of patients, the warfarin spreadsheet was developed (Figure 3):

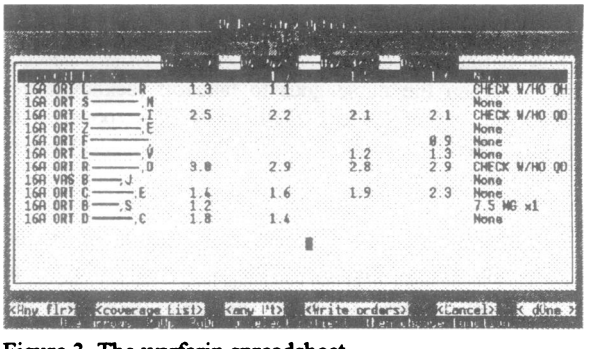

Figure 3. The warfarin spreadsheet.

The spreadsheet displays all the patients on one floor; alternatively, it can display one doctor's patient list[9]. For each patient, the normalized prothrombin times (INR) from the last four days are displayed, along with any active orders that exist for the patient. When the doctor selects a patient and chooses the Write Orders button, a second screen shows, for that patient, the four INR values, the last four warfarin doses ordered, and a bank of checkboxes. These allow the doctor to quickly select a single dose or continuing dose, to hold the medi

.cation, and other related choices. The spreadsheet allows the doctor to complete each patient's orders in

about 10 seconds, while giving added value in the organized display of the dose and lab trends. We plan to study the use of the spreadsheet with a guided-dose algorithm designed to optimize attainment of a given INR.

A spreadsheet is also used for the anesthesiologists who order dose parameters for patient-controlled analgesia. Again, the design is focused on reviewing a specific issue on multiple individual patients.

Intensive-care unit flowsheet

Each morning, physicians in our ICU conduct their rounds by traveling from one bed to another, reviewing the events of the previous day. They scan the nurse's flowsheet for current orders, lab results, and other parameters, then make their decisions for daily orders. BICS' Sign-Out system generates a printout of events, medications, lab results, and other information, similar to reports generated at the Regenstrief Institute, LDS Hospital, and elsewhere.

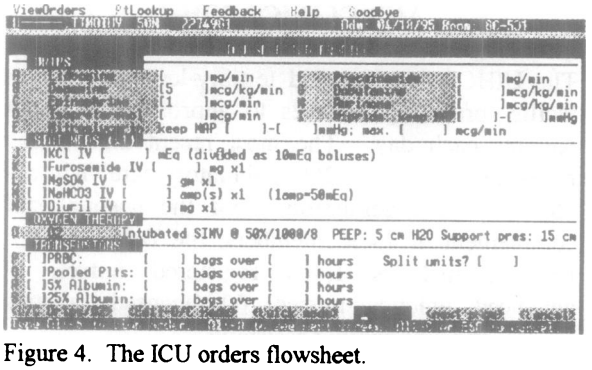

Figure 4. The ICU orders flowsheet.

The ICU orders flowsheet (Figure 4) contributes to this effort. It displays, on two screens, existing orders for pressors and antiarrhythmic drugs, IV fluids, respiratory orders, and nutrition orders. Physicians can use checkboxes to add to or modify these orders. Additional checkboxes allow orders for blood transfusions, stat labs and studies, and other selected stat medications.

Usage of the ICU flowsheet is high, particularly in the surgical units, where physicians must not only manage the ICU patients but also complete rounds in time to meet operating-room schedules.

CONCLUSION

We have identified a number of patient care processes for which a basic order entry system would not provide optimal efficiency and ideal workflow. Among these are patient transfer, discharge, and pre-admission processes, specific orders that must be applied frequently to multiple patients, and intensive care unit rounds. Augmenting our OE system allows the computer to handle the special circumstances of those processes conveniently and efficiently, and provides added value to the orderer and to the patient. Information systems departments looking to build or purchase OE systems should consider whether these processes are also vital features for their institutions.

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