Coverage List: A Provider-Patient Database Supporting Advanced Hospital Information Services

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ABSTRACT

We have developed a provider-patient database system, known as Coverage List, which maintains the associations between house staff and inpatients in a teaching hospital. Coverage List automatically links each patient to the proper resident when the patient is admitted, and updates the linkage whenever the resident coverage changes due to night or weekend coverage, physician illness, changes in clinical rotations, and other factors. Using this association, decision-support applications that detect significant clinical events can transmit them directly to the responsible resident. Sign-out and patient-review systems, which collect information on all of a physician's patients, always know the patients for whom that physician is responsible. Nurses who need to contact a physician about a patient issue always know which physician is covering that patient.

Coverage List also manages schedule entry and display for physicians, or for any other staff members. A physician can enter individual schedule changes, sign out her service and her pager for the day, and page consultants automatically without going through an operator. These functions support clinical practice directly and enhance the value of other clinical programs.

INTRODUCTION

Many hospital information systems applications share a need to know which physician is responsible for a patient at any given moment. Examples include:

- Physician order entry — to determine the primary physician responsible for co-signing orders;
- Sign-out systems and results review — to guide the physician through a review of all of her patients;
- Clinical event monitoring — so that significant events detected for a patient can be transmitted immediately to the physician;
- Medical records processing — to assign responsibility for discharge orders and summaries;
- Quality improvement programs — to determine provider-related variation in workup, treatment, and outcome [1].

Reliable, up-to-date provider-patient matching supports these services and enhances their utility. For example, when a physician reviews results or enters orders for her patients, the information system steps through a current list of patients to guide her. The computer provides a printed summary of all patients to assist her on rounds, or a consolidated to-do list to help manage tasks for the day. At the end of the day, she can use the list to review patients' progress and write sign-out notes for the night call doctor. Once she has signed out to him, his patient list shows his own patients plus the patients he is covering for her. Surveillance programs scan for abnormal lab results, new positive cultures, and other clinical events. They alert the current provider to exceptional occurrences by radio page, E-mail, and screen displays in the patient care areas.

The utility of an accurate provider-patient list extends past the computer functions themselves. Nurses and other staff members who need to page a physician about a patient-related issue often find that they have called the wrong one on the first try. Their jobs are made easier if they can easily find the name of the current provider.

Determining the identity of the responsible physician is not always a straightforward process [2]. In any hospital, particularly a teaching hospital, clinical responsibility for a patient can change frequently. The identity of the accountable physician at any given moment is subject to overnight and weekend coverage schedules, coverage for illness, changes in clinical rotation, and several other factors. For this reason, manually-maintained patient lists are often inaccurate.

We have developed a database and its suite of programs, called Coverage List, for the Brigham Integrated Computing System (BICS) [3,4], a comprehensive information system supporting a 751-bed teaching hospital. This suite consists of two main parts: a rule-based processor that handles the assignment of each inpatient to a provider who has current responsibility, and a schedule manager for entry, edit, and display of providers' jobs. Coverage List provides

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tools for easy entry, management and dissemination of schedules. These tools assist both providers and departmental administrators with these tasks.

The purposes of Coverage List are:

- to identify which provider to contact for any inpatient at any moment;
- to provide patient coverage and schedule information to other application programs as well as to people;
- above all, to be fast, friendly, and valuable enough to motivate busy physicians to use it.

OPERATION

Positions

The program's central concept is the *position* — one shift of one job. *Rotation positions* (or *primary positions*), which typically cover the patient Monday through Friday daytime, are so called because house officers often occupy them in rotations lasting weeks to months. Some, however, are permanently filled by faculty members or other attending physicians. *On-call positions*, typically nighttime and weekends, are usually occupied by a different provider each day. A *schedule* is a set of assignments of providers to positions.

The program does not associate patients directly with providers. Instead, it assigns each patient to a position (Figure 1), whose occupant takes calls about the patient. This principle is the key to separating patient-related matters like admission, discharge, and transfer from provider-related matters of rotation, sign-out, and temporary coverage. Patient coverage is a set of assignments of patients to positions; the patient and the provider meet only at the position.

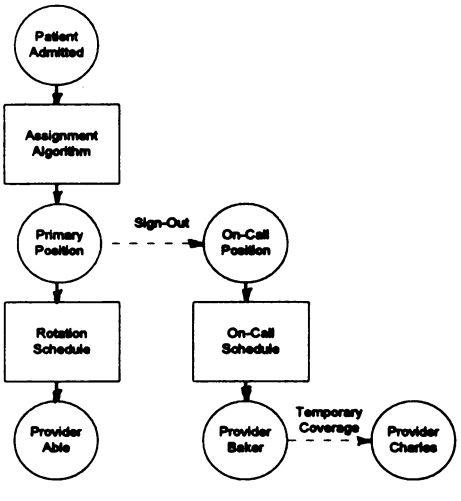

Figure 1. Assignment of patients using Coverage List.

A typical patient assignment in the cardiology service of the medicine department illustrates the concept: On admission the program assigns primary responsibility for a patient to the position "CCU Intern #2", according to the department's rules for assignment of new patients. During the day, calls go to Dr. Able, the scheduled occupant of that position. When Dr. Able signs out for the day (or at a predetermined time, if no sign-out occurs), Coverage List marks his position as signed out to the "CCU On Call Intern" position. The occupant of that position for tonight, Dr. Baker, now receives the calls and alerts. When Dr. Baker asks for a patient list or reviews her patients' current orders, she sees her own patients, plus all patients assigned to the positions that are signed out to her on-call position.

If Dr. Baker is called away from the hospital for personal illness or family emergency, she needs to ask her associate, Dr. Charles, to cover her assignments. She uses Coverage List's "Temporary Coverage" option to enter Dr. Charles' name into the database. From then on, the program diverts her patient list and her patient-related calls to him; optionally, she can forward all of her other radio pages as well. When a nurse asks who is covering this patient, Dr. Charles' name and pager number appear, followed by the names of Dr. Baker and Dr. Able with explanatory messages indicating the current chain of sign-outs. The name of the patient's attending physician, and any other clinicians concerned with the patient, are also displayed (Figure 2):

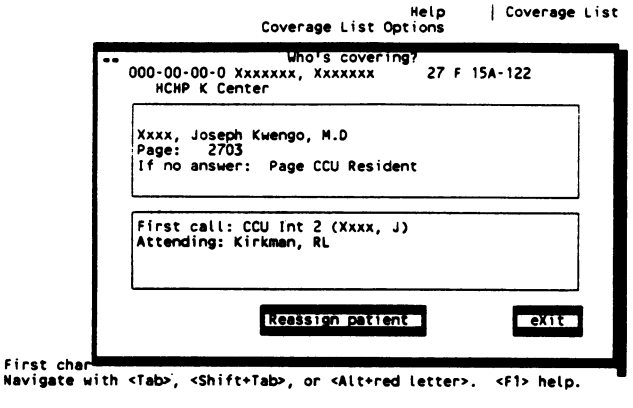

Figure 2. The "Who's covering this patient?" screen.

At the end of the month, the interns rotate to new services. Dr. Denton is now scheduled into the "CCU Intern #2" position, assuming primary responsibility for all of Dr. Able's former patients from this position.

DATABASE DESIGN

A small hierarchical database of seven parts supports the coverage list.

Department structure. This contains the names of the services and teams in each clinical department.

Providers. Linked to the BICS employee database, these records contain names, page numbers, and related information. They also indicate whether a provider is being temporarily covered by another due to illness, vacation or other cause.

Provider lists collect the names of providers into lists of faculty, attendings, residents, etc. in each department. Each position can be filled only by providers on certain lists associated with the position. This improves the speed and accuracy of entering schedules — only the first few letters of a name need be typed to identify a provider.

Positions. These attributes define a position (Figure 3):

- Its name.
- Its department, service, and team.
- Its type: rotation or on-call.
- Whether patients may be assigned to it for primary responsibility.
- Whether it appears on the hospital's consultants call list.
- Which actual patients are now assigned to it for primary responsibility.
- The provider lists that may be used to fill the position.
- Default sign-in and sign-out times for weekdays and for weekends.
- To what position it normally signs out.
- To what position it has actually signed out (if any), and when the sign-out is due to end.

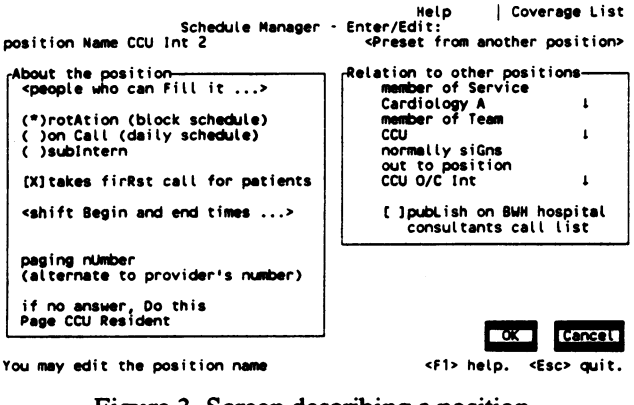

Figure 3. Screen describing a position.

Schedules are made from assignments that place one provider in one position (either rotation or on-call) from a starting date to an ending date. The universe of all assignments in Coverage List comprises a master schedule, far too large to examine or work on directly. Schedules are views of the master schedule. Each schedule contains a subset of positions and dates for easy viewing and editing. Multiple views of the same assignments are often used for convenience.

Patient responsibility. First call responsibility links each patient with exactly one position. Calls go to the last provider found in this sequence (See also figure 1):

1. The occupant of the primary position;
2. When this position is signed out, the occupant of the position to which signed out, iterated over a chain of sign-outs if necessary;
3. Whoever, if anyone, is temporarily covering for the provider found in 1) or 2), iterated over a chain of temporary coverage if necessary.

Inverted indexes. Outnumbering the base files 23 to 11, indexes provide rapid access to data in forms convenient for applications, for example, alphabetic lists of providers to fill a position.

FUNCTIONAL DESIGN

Schedule management

A schedule manager (usually a secretary or administrator) in each department administers the coverage list database, mostly by creating and modifying schedules. A table tool similar to a spreadsheet makes this task faster and easier than entering schedules on paper. The tool checks for conflicting assignments and distributes changes throughout the institution.

Schedule managers also maintain their departments' lists of providers, and they occasionally define new positions. Specific Coverage List functions perform these tasks.

User functions

Although the coverage list deals internally with positions and their occupants, it hides this concept from its users. Persons sign out to other persons, transfer patients to other persons, and cover for other persons.

The full-screen user interface (Figures 2, 3, and 4) is displayed with characters, not full graphics, but it works like Microsoft Windows™ to present the coverage list functions in a familiar environment.

Service sign-out is used by the primary physician at the end of the day to transfer responsibility for her patients to the on-call physician. As a fail-safe

measure, if the departing doctor fails to use this function, Coverage List still assigns the patients to the on-call position at a designated time. As an incentive for physicians to use this function, the doctor can use this screen to change her radio page status to "out of hospital" without the need to call a telephone operator. She can also have the computer page the on-call doctor, so the two can meet to discuss patient issues. Additionally, the BICS Inpatient Sign-Out system [5], which is widely used to communicate patient status and data to the on-call provider, has a button to open this screen.

The primary physician can use the **Sign In** function to reactivate her pager and reclaim her patients when she returns to the hospital. Sign-in also occurs automatically at a designated time. If she does not do this explicitly, the program does it for her at the time she gave when signing out (Figure 4).

Physicians sign out about 1000 times per month and sign in about 20 times per month.

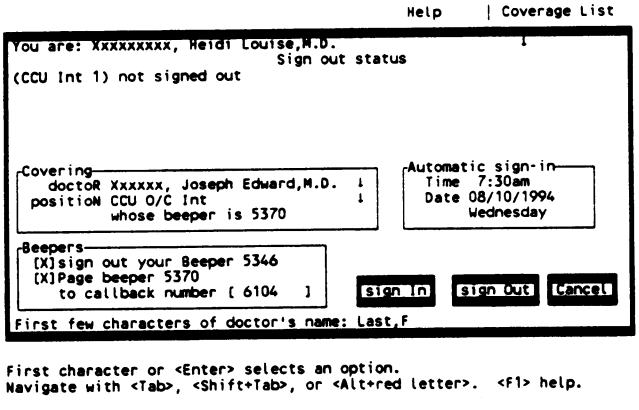

Figure 4. Service Sign-Out

View/Edit Patient List. The physician can view and print a list of those patients for whom he has first call responsibility and, when on call, those whom other providers have signed out to him. Team lists combine the patient lists of all providers on a care team, showing which physician is responsible for each patient. Patient rosters embellish the team list with admitting diagnoses and procedures from the computer, and notes added by members of the teams.

Sometimes, patients are reassigned arbitrarily to a different physician from the one determined by the department's rules. For example, a ward resident may determine that the intern who is supposed to receive a new patient has too many patients already, so the patient is assigned to another intern. "Add" and "Reassign" buttons on the Patient List screen allow Coverage List to keep track of these discretionary reassignments.

The **"Who's covering?"** function displays the physician responsible right now, her radio page number, whom to page if she does not answer, and the chain of sign-outs and temporary coverage back to the provider primarily assigned to the patient. Because of the popularity of this function, the name of the currently responsible physician now also appears at all times on the main patient-lookup screen. A "Who's on call?" screen shows names and page numbers of consultants and others on call right now, and offers to page them; this reduces the number of calls to the telephone operators.

View/Edit Your Schedule Assignments. Each physician can view or print his personal schedule, assembled from the universe of all schedule assignments. If a physician wishes to trade an on-call assignment with another physician, a parallel display box appears and shows the other physician's schedule. By marking one assignment in each physician's list and pressing a button, the assignments are changed in the database. The program warns of resulting conflicts and sends a confirming E-mail note to the parties involved and to the department's schedule manager.

Display Schedules. Anyone can display or print a department's schedules in a tabular format. One of the benefits of Coverage List is that a schedule change made at any workstation is immediately available at any other location in the hospital. This is in contrast to paper schedules, where a change would need to be made in every location where the paper schedule is posted.

PATIENT ASSIGNMENT ALGORITHMS

When a patient is admitted or transferred, departments assign the primary provider in many different ways: according to the patient's room, the team, the attending physician, the junior physician on the operating team, the resident on call tonight, and sometimes by combinations of these items. Some departments do not codify the process; the chief resident makes the assignments for each patient individually.

When a department establishes or changes its rules for assigning patients, a programmer encodes the rules in the M programming language and encapsulates the code into "methods" for inclusion in the database, either directly or by reference. The hospital admissions program sends admissions, transfers, and discharges to these patient-assignment "objects," which assign primary responsibility using the rules contained in the method. The patient appears on a physician's list without manual entry.

As noted, patients are sometimes assigned outside the rules for load-balancing and other needs. The

"Add" and "Reassign" buttons present on several screens adjust Coverage List's assignments as needed. About 8% of inpatients are reassigned this way during their stay.

USAGE

Clinicians' schedules and patient assignments are valuable to many other applications, from the critical (paging the right physician for a life-threatening lab result) to the mundane (determining who gets cafeteria vouchers for night call duty). A doctor can instruct the results-reporting system to step through her patient list or the team's patient list, reducing errors of omission. The BICS physician order entry system [6] optionally displays a physician's patient list, which not only allows quick access to any patient's orders but also provides an instant display of which patients need renewals or co-signatures, and which have pending alerts.

When signing out at the computer, physicians examine and edit patient summaries, guided by the same patient list, for the on-call physician's use [5,7]. Data suggests that these sign-out notes have reduced the increased risk of adverse events found in cross-covered patients [8]. The new BICS event-processing engine contains agents that monitor significant clinical events and send E-mail or radio pages to the appropriate covering physician [9].

Several other programs make use of Coverage List functions. During sign-out, the program sends changes in radio page status through a link to the hospital paging system. The new status tells any future caller not only that the doctor is signed out, but which doctor is now covering the service. Coverage List supplies the medical records department with a list of clinicians who worked with each patient, to assist the medical records staff in completing their records and chart analysis.

CONCLUSIONS

Usage of Coverage List is high: BICS users run programs from its menu an average of 300 times per day. Other applications call on its functions 400 times per day. Most of the hospital's clinical departments now use the schedule management functions. The ability of providers to modify their own schedules is popular with clinicians and administrators alike. Job schedules are valuable for non-providers as well. One department has completely replaced the in-house mailing of paper schedules with locally printed, up-to-date schedules from the computer.

We have found Coverage List to be a well-accepted and useful adjunct to the BICS system. It eases the job of secretaries who enter schedules, telephone operators who take calls for primary physicians and consultants, nurses and others who need to contact a patient's physician, and physicians who want to keep their patient lists up-to-date. The automatic patient list minimizes data entry by physicians, who need only enter exceptions to the program's assignment of primary responsibility for patients, thus lowering one barrier to acceptance of the HIS. Although work must be done by the programmer to construct the patient assignment algorithms for each department, programmer maintenance is low once these have been encoded.

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