Automated Lab Test Follow-up to Reduce Medical Errors

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ABSTRACT

Purpose: To ensure proper handling of late-arriving laboratory results in our pediatric emergency department (ED), we developed a computerized system called the Automated Late-Arriving Results Monitoring System (ALARMS). We evaluated the accuracy of ALARMS, measured rates of adequate follow-up for late-arriving abnormal laboratory results prior to implementation of ALARMS, and then measured the quality of follow-up after clinical use of ALARMS began.

Scope: The study was performed prospectively in the ED of a tertiary care pediatric hospital.

Methods: In Phase 1 of the study, we measured the sensitivity of ALARMS for detecting late-arriving abnormal laboratory results identified by a manual review. In Phase 2, rates of appropriate follow-up for late-arriving laboratory results in our ED prior to implementation of ALARMS were calculated. In Phase 3, follow-up rates after implementation of ALARMS will be compared to rates prior to implementation.

Results: In Phase 1, ALARMS accurately detected 323/324 (99.7%) late-arriving abnormal laboratory results identified by our manual review. In Phase 2, we studied 924 late-arriving abnormal laboratory results for which follow-up with the patient was indicated. Follow-up was successfully completed for 762 (82%) of these results, and complete follow-up was documented in the hospital medical record for 697 (75%) results. The most common abnormal results for which follow-up was not completed were urine cultures (22), strep throat cultures (22), Epstein-Barr virus titers (10), and stool cultures (9). ALARMS has now been implemented for clinical use, and Phase 3 data collection is ongoing.

Key Words: laboratory results, patient safety

PURPOSE

Introduction

Failure to respond to abnormal laboratory data in a timely fashion is a frequent cause of medical errors. Although this problem is universal in medicine, it may have special importance in the Emergency Department (ED), because results from certain laboratory tests may return hours or days after patients have been discharged. Unless ED clinicians make a special effort to arrange follow-up, they may not remember to check late-arriving results for patients no longer in their care.

To address this issue, we have developed a computerized system called the Automated Late-Arriving Results Monitoring System (ALARMS). The purpose of ALARMS is to generate a log of all late-arriving abnormal laboratory results in the ED, to prompt the user to make a response to each abnormal result and document this response in the patient's medical record.

The specific purpose of this study was to:

(1) Evaluate the accuracy of ALARMS
(2) Use ALARMS "offline" as a research tool to study the quality of the ED's follow-up systems prior to implementation of ALARMS
(3) Measure the impact of ALARMS, once implemented, on rates of follow-up
(4) Evaluate the cost of ALARMS, in terms of time "wasted" by clinicians addressing clinically unimportant laboratory results

In order to achieve our goals, our study tested the following four hypotheses:

(1) ALARMS performs accurately, with very high sensitivity and specificity for detecting late-arriving abnormal laboratory results.
(2) By failing to ensure appropriate follow-up for a substantial number of abnormal laboratory results, the follow-up systems in our ED (prior to implementation of ALARMS) allowed for many medical errors.
(3) Once ALARMS wass implemented, rates of medical errors**,** in the form of inadequate follow-up for late-arriving laboratory data, decreased significantly.
(4) Clinicians using ALARMS spend relatively little time addressing laboratory results that do not require follow-up.

SCOPE

<u>The problem of late-arriving laboratory data:</u>

Failure to act on results of monitoring or testing is generally considered one of the cardinal forms of medical errors. This problem has special importance in the Emergency Department (ED), because results from certain laboratory tests may return hours or days after patients are discharged. Because these patients are no longer in the care of the ED, the clinicians in the ED may not remember to follow-up on these laboratory results.

Prior to the implementation of ALARMS, our ED utilized several mechanisms to ensure follow-up of late-arriving laboratory results. Results considered "critical" by the laboratory were reported immediately to the ED by telephone. Bacteriologic culture data were reported on a daily printout reviewed by ED physicians. For other tests anticipated to have late-arriving results, the ordering physician in the ED generally attempted to identify a clinician who would follow up. However, there was no system to ensure that these results were reviewed.

In a retrospective study completed in 1998 in preparation for this investigation, we used a prototype of ALARMS to analyze retrospectively our ED's rate of documented follow-up for certain late-arriving lab results. We chose three types of tests for study: *Chlamydia* cultures, blood lead levels, and urine pregnancy tests. We chose these three tests because their results sometimes or always return after patients have been discharged and because none are reported automatically by the lab.

We used a prototype of ALARMS to generate a list of all late-arriving abnormal results of these tests, if ordered for ED patients between May 1996 and April 1998. We then examined the medical records to look for documented evidence of follow-up on these late-arriving results. The results are shown below:

Test Name	Total Number of Abnormal Results	Number (percent) with appropriate follow up documented
Lead levels	18	12 (67%)
Urine pregnancy tests	4	1 (25%)
Chlamydia cultures	39	16 (41%)

One adverse event, likely attributable to inadequate follow-up, was identified: a 19 year-old woman with a positive cervical culture for *Chlamydia* returned to the ED 6 weeks later with pelvic inflammatory disease.

Many medical errors classifiable as potential causes of adverse events were identified as well. These included 16 (41%) of the 39 *Chlamydia* cases in which no treatment for the infection was prescribed. The six cases of abnormal lead levels, ranging from 11-28 mcg/dL, were also considered potential causes of adverse events. No form of treatment was initiated for these six patients, despite the fact that all of these lead levels were in a range for which medications and investigation of the home environment were indicated.

This study was limited by the inclusion of only a small subset of all laboratory tests ordered in the ED. Nonetheless, we found a substantial rate of medical errors in the form of inadequate follow-up for the three laboratory tests we studied. Based on these data, we expected that ALARMS could have a significant impact on the rate of medical errors in the ED.

To understand the scope of the problem of late-arriving laboratory data in pediatric emergency medicine, in November 2001, we surveyed 22 pediatric EDs in the United States. The EDs were chosen to represent some of the field's leaders in patient care and research. Twenty of 22 EDs (91%) responded to our e-mail questionnaire. The 20 responding EDs had a mean annual patient volume of 47,800 (range 20,000-91,000). Seventeen of 20 (85%) offered a pediatric emergency medicine fellowship, and 12/20 (60%) were on the *US News and World Report* 2001 list of "America's Best Hospitals."

Three of 20 (15%) EDs had no active follow-up systems. These EDs generally asked referring physicians to follow up on results. Of the 17 EDs who did report active follow-up systems, three (15%) covered only some types of lab results (like our ED's system for bacteriologic culture results). Another 11 (55%) required the work of clinicians to identify late-arriving abnormal lab results. Seven (35%) EDs, for instance, asked clinicians to make an entry into a log at the time that the test is ordered, requesting subsequent follow-up checks from colleagues.

Only three EDs (15%) reported automated systems that covered all types of lab results; none of these three systems prompted the user to document follow-up.

Six EDs (30%) reported that there was "frequently" inadequate follow-up for late-arriving lab results in their ED, and nine EDs (45%) reported that there was "frequently" inadequate documentation of follow-up. Only five EDs (25%) said that there was "almost never" inadequate follow-up for late-arriving lab results in their ED.

Application of medical errors theory to the problem of late-arriving laboratory data:

Medical errors theory distinguishes between latent errors and active errors. Latent errors can be considered hidden design flaws, systems problems that lead to the commitment of active errors by individual workers. Although the active errors are most visible to outside observers, it is really the latent errors that are the root of the problem.

The problem of late-arriving laboratory data in the ED is well understood using this model. The latent error is that there is no automatic system to ensure follow-up for late-arriving results. Follow-up for late-arriving results occurs only if clinicians make a special effort to keep checking the results, sometimes for several weeks after a patient is seen. In this system, it is not surprising that active errors – cases in which follow-up is not completed – occur commonly. The solution is to build a system that does not require clinicians to make such an extraordinary effort to provide good care.

A computerized system to assist with late-arriving laboratory data:

Previous investigators have demonstrated success in using computerized alerts and reminders to ensure that physicians perform certain clinical actions in a timely fashion. Some authors have shown that physicians are more likely to respond appropriately to laboratory test results if they are automatically informed of the abnormal results.

To address the problem of late-arriving laboratory data in the ED, we developed a computerized system to assist in alerting emergency physicians to late-arriving laboratory results as soon as they become available. We call the system the Automated Late-Arriving Results Monitoring System (ALARMS).

The problem of medical errors attributable to inadequate follow-up of late-arriving laboratory data is not unique to our ED. Our intention in pursuing this research study was to establish whether ALARMS was effective in our ED so that it might be adapted to other Emergency Departments, inpatient wards, and outpatient clinical settings.

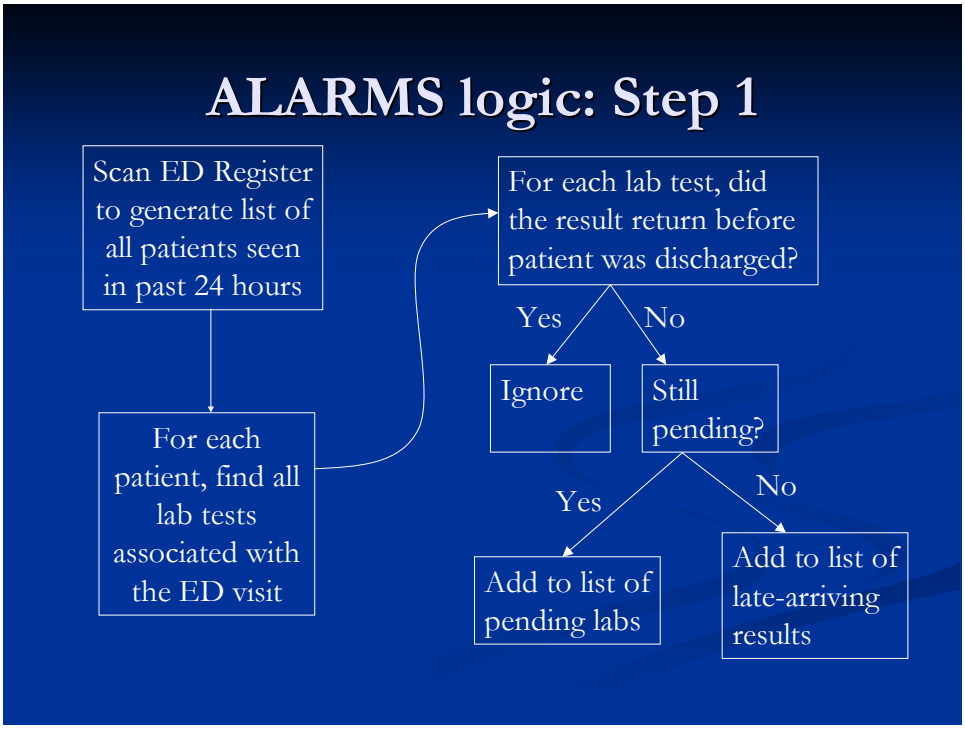
Conceptual model of ALARMS:

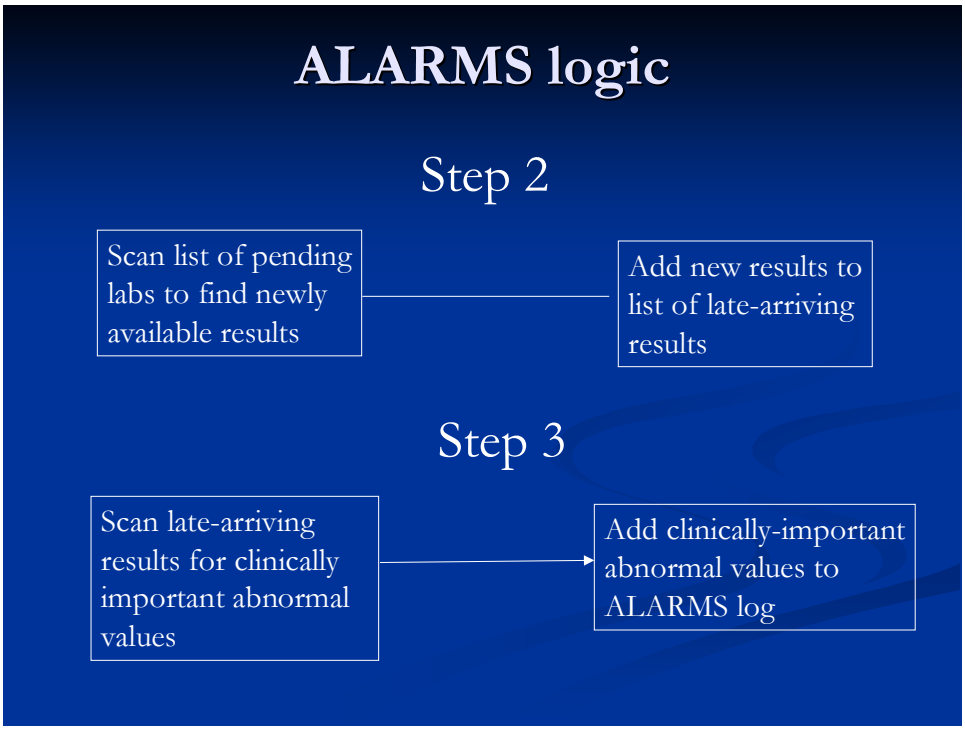
The purpose of ALARMS is to achieve two principal goals: (1) ALARMS reviews all results for laboratory tests ordered in the ED in order to generate a log of all late-arriving abnormal laboratory data. (2) ALARMS allows clinicians in the ED to review this log and to generate a note documenting a response to the laboratory result.

ALARMS queries an Oracle database of patient information maintained on the hospital's mainframe VAX computers. ALARMS is accessed by authorized clinicians using a web-based interface via the Children's Hospital intranet.

Generating the ALARMS log:

Once each day, ALARMS uses the following logic to generate the log (see figure below for schematic representation):





(a) ALARMS scans the ED Register, a prospectively maintained record of all registrations in the department, to generate a list of all patients seen within the past 24 hours. For each patient, the time of arrival to the ED and discharge from ED are noted.

(b) ALARMS queries the hospital's laboratory results system to identify all lab tests originating from each patient visit in the ED. Lab tests are defined as originating from the ED if the specimen arrived in the laboratory between the patient's computer-stamped ED arrival time and 2 hours after the computer-stamped discharge time.

(c) From the list of all laboratory tests ordered in the ED, ALARMS checks individual results to determine if the time the result was reported electronically by the laboratory is later than the ED discharge time. If so, the result is considered to be late-arriving. Results that are still pending are stored in a separate list of pending results.

(d) After the day's laboratory results are checked, ALARMS scans the "pending list" to determine if any pending laboratory results from previous days have now become available. If so, they are added to the ALARMS list of late-arriving lab results.

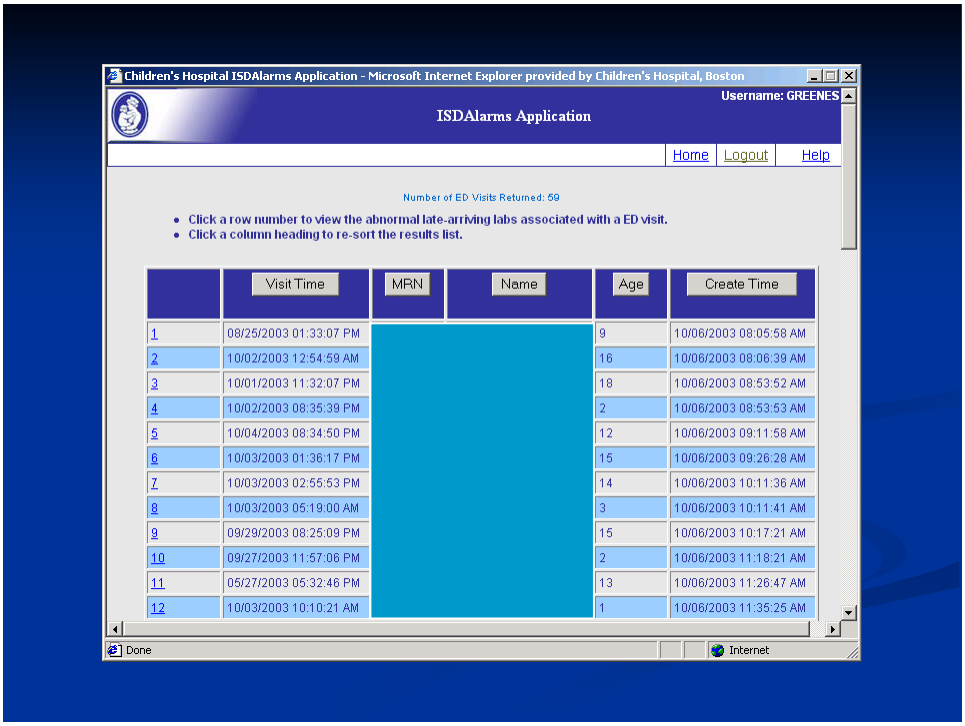
(e) ALARMS scans the list of all late-arriving results and check the results against a set of rules to determine whether they are abnormal values. In most cases, ALARMS compares the test values to the normal ranges established by the laboratory.

(f) Each abnormal late-arriving result is added to the electronic ALARMS log.

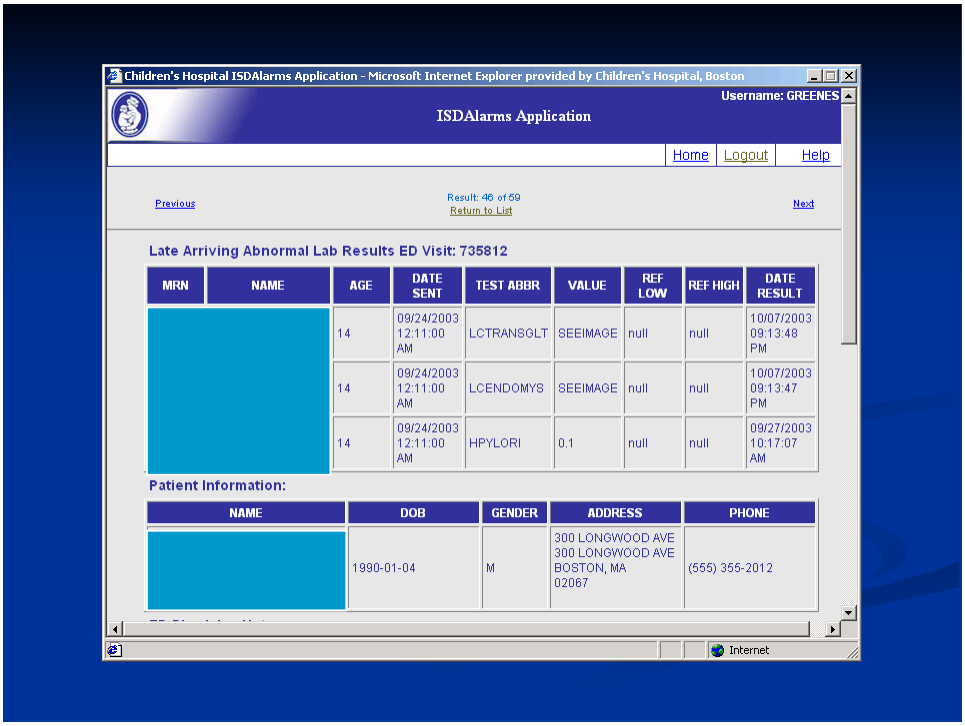
User interface:

ALARMS is accessed by authorized clinicians using a web-based interface. To maintain patient confidentiality, the system is accessible from the hospital intranet within the Children's Hospital "firewall." Each day, a designated attending physician in the ED is assigned the task of reviewing the ALARMS log. We believe that daily assignment of the task of reviewing the log is more failsafe than asking individual ordering physicians to perform their own follow-up.

The graphics that follow show how the user interface works. After logging on to the system (authenticated with username and password), the user views the "top page" of the ALARMS log, in which each line on the screen represents a single ED patient with late-arriving abnormal laboratory results. In the graphic that follows, the medical record numbers and names are blocked out to protect patient privacy.

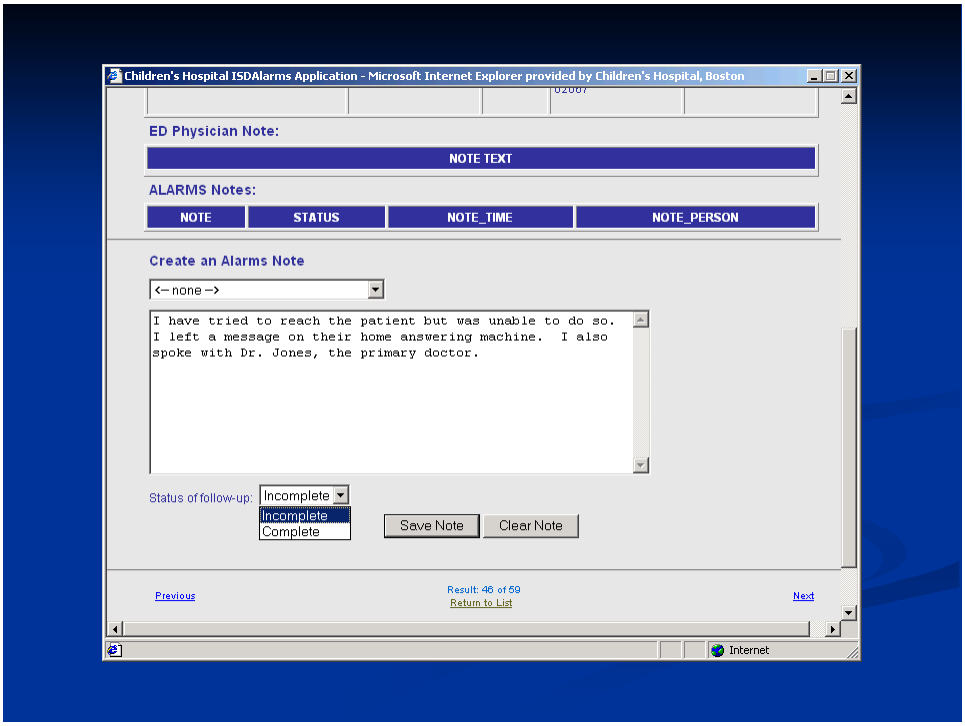


By clicking on any individual test result, the user opens a "detailed" window, which has more information about that result:



At the top of the detailed page, the user finds the full text of the laboratory result followed by contact information for the patient and the primary care provider.

At the bottom of the "detailed" window is a dialog box in which the user constructs a note documenting a response to the laboratory result.



In many cases, the note will include documentation that the result was communicated to the patient and the referring physician. Specific clinical recommendations (such as new medications or return visits for further care) are documented here. Once a clinician indicates that the note is complete, it is exported to the hospital computer system to become part of the patient's electronic medical record.

METHODS

Setting:
The study was performed in the ED of Children's Hospital, Boston, a 300-bed pediatric hospital. The ED has a volume of approximately 50,000 patient visits per year.

Phase 1: Accuracy of ALARMS
Phase 1 of the study was completed with ALARMS running in "the background" (that is, without being implemented for clinical use). The purpose of Phase 1 was to test the hypothesis that ALARMS performs accurately, with near-perfect sensitivity for identifying late-arriving abnormal laboratory results.

Data collection:

Each day, a research assistant manually reviewed all laboratory results for all patients seen in the ED the preceding day.

The research assistant used the prospectively maintained Emergency Department Log to generate a list of ED patients and checked all results on the hospital's laboratory information system. All late-arriving results were collected. All of these late-arriving results were reviewed with the principal investigator to determine whether they qualify as reportable abnormal results (as defined by the rules used in ALARMS). In doing this assessment, the researchers were blinded to the content of the log generated by ALARMS.

Data analysis:
The results reported in the ALARMS log were checked against the results of the manual review, which were considered the criterion standard. The sensitivity of ALARMS for detecting lab results generated by our manual search was calculated. Furthermore, notation was made of all cases found by ALARMS, but not by our manual search. All discrepant cases were reviewed by the primary investigator.

Sample size:

To feel confident that the system is clinically dependable, we would want ALARMS to have a sensitivity of 100%. In order to prove 100% sensitivity with narrow confidence intervals, the goal was to have ALARMS to perform perfectly on a sample of at least 300 late-arriving abnormal laboratory results (generating sensitivity 1.0 [95% CI 0.99, 1.0]).

Phase 2: Quality of Follow-up in the ED Prior to Implementation of ALARMS

Phase 2 began after Phase 1 was complete, with ALARMS still running in the background. The purpose of Phase 2 was to test the hypothesis that the ED's follow-up system prior to implementation of ALARMS failed to provide adequate follow-up for a substantial fraction of late-arriving results.

Outcome measures:

For Phases 2 and 3 of the project, two principal outcome measures were assessed. First, cases were considered to have *adequate follow-up* if the patient and/or family were notified of the abnormal result within 72 hours of the result becoming available and were given instructions about any necessary further investigation or therapy. Second, cases were considered to have *adequate documentation of follow-up* if there was recorded evidence in the medical record of the follow-up notification and plan.

As a secondary outcome measure, data were collected about any *adverse events* associated with the late-arriving abnormal laboratory results. The study investigators determined as a consensus panel whether any clinical changes in a patient's status were attributable, or potentially attributable to the late-arriving laboratory result.

These evaluations were based on the consensus of at least two reviewers, with a third reviewer available as a "tie breaker."

Data collection:

Each Wednesday, a research assistant reviewed the ALARMS log for all late-arriving abnormal results returning within the week ending on the preceding Saturday. For each abnormal result, the medical record was reviewed for documented evidence that a physician had completed follow-up for the laboratory result. If there was documented evidence that the physician followed-up on the result within 72 hours of its report, the result was considered to have *adequate documentation and adequate follow-up*.

For each abnormal result without documentation of adequate follow-up, a telephone call was made to the patient or family to inquire as to whether the family was notified of the result. If the family was notified and given instructions for follow-up, the result was considered to have *adequate follow-up but not adequate documentation*. Any patient who had not been contacted was considered to have inadequate follow-up. In these cases, study investigators inquired about the patient's clinical status to assess for any changes that might constitute adverse events. Full details about these clinical changes were recorded.

Data analysis:

Rates of *adequate follow-up* and of *adequate documentation* were calculated, with 95% confidence intervals. As a secondary measure, rates of *adverse events* were calculated. The data from Phase 2 are descriptive and form a baseline for comparison with the data from Phase 3. Because of logistical delays in the implementation of ALARMS for clinical use, Phase 2 was continued for 8 months rather than the 3-month period initially planned.

Phase 3: Quality of Follow-up Post-Implementation of ALARMS

Phase 3 of the project is still ongoing. The purpose of Phase 3 is to continue to collect data about rates of adequate follow-up and adequate documentation, as defined above, after ALARMS was introduced for clinical use. In Phase 3, we test the hypothesis that rates of adequate follow-up and documentation are significantly improved after the introduction of ALARMS.

Data collection:

Data collection continues, in a manner identical to that described in Phase 2 above, for a 12-month study period. This 12-month study period allows us to describe the entire scope of late-arriving laboratory results, accounting for seasonal variations (Lyme titers, for instance, will be ordered primary in the summer and fall). In addition, we will be able to assess for trends in the efficacy of ALARMS over time.

It is possible, for instance, that there will be initial interest in ALARMS when it is first introduced but that use of the system will decline over time. On the other hand, there may be a "learning curve" with increased use of ALARMS as clinicians become convinced of its utility.

Data analysis:

Rates of adequate follow-up and adequate documentation of follow-up from Phase 3 will be compared with rates from Phase 2 using chi-squared analysis. As secondary analysis, we will compare the rates of adverse events in Phases 2 and 3. In addition, secondary analysis will include a time series analysis to assess for time trends, as described above.

Sample size:

Our database from Phase 2 include 924 late-arriving laboratory results. Based on these data, we expect to have approximately 1300 results in Phase 3. Given a rate of at least partial follow-up for approximately 90% of results in Phase 2, we expect to have a power of 0.8 to detect an improvement to a follow-up rate of 93% and a power of 0.99 to detect an improvement to a rate of 95%.

Phase 4:

Phase 4 will be pursued after Phase 3 is complete. The purpose of Phase 4 will be to collect additional data regarding the utility of ALARMS. Although we expect that ALARMS will be a useful addition to clinical practice in the ED, we recognize also the potential for some costs of ALARMS.

In Phase 4, we will assess some potential costs of ALARMS, including (1) time spent by physicians using ALARMS, (2) time wasted on lab results ultimately deemed to be clinically irrelevant, and (3) time wasted on telephone calls to patients, ultimately deemed unnecessary by the operator. Knowledge of these costs will help inform clinical decision making about whether to adopt a system like ALARMS.

Data collection:

Each day, a designated attending physician in the ED will be assigned the task of reviewing the ALARMS log. During Phase 4, a research assistant will accompany the ED physician as s/he performs this review. For each entry (i.e., each abnormal result) on the ALARMS log, the research assistant will record the time spent by the ED physician working on that entry and the ED physician's assessment of whether or not the result is clinically relevant and requires follow-up. For each case in which a follow-up call is made, the research assistant will record the ED physician's report of whether or not the patient had already been aware of the result prior to the call.

Data analysis:

Data analysis for Phase 4 will be descriptive. Average amount of time per ALARMS entry will be calculated with a comparison of the time spent on those results that do or do not require follow-up calls. In this manner, we will be able to estimate the total time invested in using ALARMS per clinically important result.

Limitations of our project

Our research focuses on the measurement of medical errors. Although we attempt to detect adverse events attributable to these errors, we expect these adverse events to be relatively uncommon. Our study may not have adequate power to detect a difference in rates of adverse events. Furthermore, our research design likely interferes with the natural history of the medical errors we study, because ethical considerations require us to provide appropriate follow-up recommendations to patients and families when we call them. Thus, our study may lead to a decrease in the rate of resulting adverse events. For these reasons, we chose not to make adverse events a primary outcome measure for the project.

Our study's principal outcome measure is the performance and documentation of follow-up calls to patients. Even if follow-up calls are made, the patient and family may not understand the information that has been conveyed, and they may fail to pursue the recommended actions. The likelihood of a patient actually achieving the complete recommended follow-up probably depends on a variety of personal, social, cultural, and economic variables. We must recognize, therefore, that a system that helps to guarantee that a follow-up call occurs is only the first in many steps in improving care for patients after late-arriving laboratory results become available.

Human Subjects Approval

This protocol was approved by the Children's Hospital Committee for Clinical Investigation as protocol #01-04-059R. A waiver of the requirement for written informed consent was obtained.

RESULTS

Phase 1 – Accuracy of ALARMS

During Phase 1, a research assistant manually reviewed late arriving laboratory results for ED patients and compared the output of the ALARMS log. For this analysis, the manual review was considered the gold standard. Data were collected until there were late-arriving abnormal laboratory results for more than 300 distinct ED visits. Overall in this analysis, 324 laboratory results were reviewed. ALARMS successfully detected 323 (99%) of these 324 results. For the one result that was missed by ALARMS, it was impossible to determine from the medical record whether the laboratory test was actually ordered from the Emergency Department (versus the inpatient ward to which the patient was subsequently admitted).

Excluding this one questionable result, we determined the sensitivity of ALARMS to be 1.0 (95% confidence interval 0.99, 1.0) for detecting late-arriving abnormal results for laboratory tests ordered in the ED.

Phase 2 – Data collection prior to implementation of ALARMS for clinical use

Data were collected from July 1, 2003, through February 28, 2004. Over this period of time, 1161 late-arriving abnormal laboratory values were returned. The most common types of abnormal laboratory values are shown in the table below.

Type of Laboratory Test	**Number (Percent)**
Urine culture	301 (26%)
Glycosylated hemoglobin	128 (11%)
Throat culture	106 (9%)
Blood culture	93 (8%)
Serum protein analysis	34 (3%)
Cerebrospinal fluid culture	33 (3%)
Epstein-Barr Virus titers	28 (2%)
Stool culture	28 (2%)
Thyroid function tests	23 (2%)
Lyme titers	19 (2%)
Chlamydia antigen test	14 (1%)
Erythrocyte sedimentation rate	12 (1%)
Sputum culture	11 (1%)
Clostridium dificile toxin assay	10 (1%)
Pyruvate (serum)	9 (1%)

Of the 1161 late-arriving laboratory results obtained, we determined that follow-up with the patient was necessary for 924 (80%) of the results. For the other 237 (20%) results, we determined that notification of the referring physician (without necessarily contacting the patient) would be sufficient. For instance, a patient with a diagnosis of Kawasaki disease would be expected in most cases to have an elevated erythrocyte sedimentation rate (ESR). If the diagnosis had already been made and appropriate therapy initiated, we deemed it unnecessary to notify the patient about the elevated ESR value in such a case.

We examined whether appropriate follow-up was completed for the 924 results for which follow-up was indicated. Results of this analysis are presented in the table below.

Description of Follow-Up	**Number (percent)**
Follow-up completed by an ED physician	252 (27%)
Follow-up completed by a non-ED physician	510 (55%)
Follow-up completed because the patient or family called for the result	7 (1%)
Partial follow-up (e.g., message left) by an ED physician	31 (3%)
Partial follow-up by a non-ED clinician	35 (4%)
No follow-up done	89 (10%)

We next examined whether appropriate follow-up was *documented* for the 924 patients for whom follow-up was indicated. Results are presented below:

Description of Documentation of Follow-up	**Number (percent)**
Complete follow up documented by an ED clinician	298 (32%)
Complete follow-up documentation in the Children's Hospital medical record by a non-ED clinician	399 (43%)
Partial documentation of follow-up (e.g., follow-up plan documented, but communication with family not confirmed)	51 (6%)
No documentation of follow-up	186 (20%)

Cases in which follow-up was indicated but not completed were reviewed in detail. Below is a tabulation of the types of lab results for which complete follow-up was not documented:

Bacteriology

Throat culture: positive for strep	22
Urine culture positive	22
(E. coli 16, *Klebsiella* 2, *Staphylococcus* 2, *Enteroccus* 1, *Pseudomonas* 1)	
Stool culture positive	9
(*Salmonella* 6, *Shigella* 1, *Campylobacter* 2)	
Blood culture positive for *Salmonella*	1
Blood culture positive for *Corynebacterium*	1
Positive *Clostridium dificile* toxin assay	4
Positive genital assay for *Chlamydia*	3
Positive genital culture for gonorrhea	1
Positive *Mycoplasma* antibody	3

Elevated *H. pylori* titer	3
Positive *Bartonella* titers	2
Positive *Pertussis* titers	1

Virology

EBV titers positive	10
CMV titers positive	3
Rapid antigen test for influenza	2
Rapid antigen test for parainfluenza	1
Rapid antigen test for RSV	1
Viral culture positive for adenovirus	1

Endocrinology & Metabolism

Elevated thyroid stimulating hormone	4
Elevated anti-insulin antibodies	2
Elevated parathyroid hormone	1
Elevated ACTH level	1
Low cortisol level	1
Elevated plasma renin activity level	1
Abnormal urine organic acids	1

Allergy and Immunology

Elevated erythrocyte sedimentation rate	1
Positive RAST for latex	1
Positive RAST for peanuts	1
Abnormal IgG subclass analysis	1

Hematology

Low serum iron	1
Abnormal von Willebrand factor level	1

Other

Elevated cardiac troponin	1
Positive urine pregnancy test	1

Phases 3 and 4

ALARMS is now being used on a daily basis by ED clinicians to assist in the completion of follow-up for late-arriving abnormal laboratory results. Data collection continues for Phase 3 at the current time, with Phase 4 data collection to follow.

The system has been very well received by clinicians, who have been impressed by the quantity of late-arriving laboratory results reported by ALARMS. The general sense among clinicians using the system is that many of these results would not have been noted or documented by ED physicians if ALARMS were not available. One drawback of ALARMS that has become evident, however, is the fairly regular appearance of "trivially" abnormal laboratory results that actually require no response, on the ALARMS log. We are working to customize ALARMS to automatically exclude some of these trivial abnormalities. We will quantify more precisely the burden of these reports of trivially abnormal results in Phase 4.

Discussion and Implications

Our research has shown that failure to follow-up on late-arriving abnormal laboratory results is common in our Emergency Department, occurring for approximately 10% of all late-arriving laboratory results. Perhaps of even more significance, however, is the fact that, in most cases in which successful follow-up did occur, follow-up was completed by clinicians outside the ED or even by the patients (and their families) pursuing the appropriate follow-up themselves. The ED physicians completed follow-up calls themselves for only about 27% of all late-arriving abnormal laboratory results.

Medicolegally, ED physicians should probably be considered responsible for ensuring follow-up for all laboratory tests that they have ordered, no matter who is caring for the patient when the results of those tests become available. Our data clearly show that the systems the ED was using to ensure follow-up prior to the implementation of ALARMS were inadequate. Even with the existence of the ED's daily report of bacteriologic cultures, our data show that positive cultures were the most common type of laboratory result for which the ED failed to complete follow-up.

We expect that the implementation of ALARMS will lead to marked improvements in the rates of follow-up, and documentation of follow-up, for late-arriving laboratory results in the Emergency Department. If ALARMS proves successful, we believe that widespread adoption of this or similar technologies will address a fundamental source of medical errors in emergency departments and other clinical settings.

Publications related to this research project. (These publications preceded the grant award. To date, here has been no output specifically stemming from the funded project.)

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