

# Case Studies in Medication Safety Improvement

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The problem of medication errors in health care has been well documented [1], and reducing medication errors has become an important goal in health care organizations. High-technology approaches, such as computerized physician order entry, have achieved impressive results in improving the medication process [2]. However, improvements to medication safety may also be achieved through the implementation of low-tech process changes that can be implemented fairly rapidly and inexpensively. This article reports on the work and the results of 6 hospital teams that achieved improvements in ordering, dispensing, and administering medication at their institutions using relatively low-technology interventions and rapid-cycle improvement techniques.

## Background

CareGroup is a large integrated delivery system in eastern Massachusetts made up of 5 hospitals and a number of affiliated physician groups and community health centers. The hospitals are Beth Israel Deaconess Medical Center (BIDMC), Deaconess-Glover, Deaconess-Nashoba, Mt. Auburn, and New England Baptist. Another hospital, Deaconess-Waltham, was a member of CareGroup until the spring of 2002. The system has more than 13,000 employees, including 2000 medical staff.

In 1998, James Reinertsen, CareGroup's chief executive officer, established for CareGroup the goal of becoming the world standard in medication safety. Jeanette Clough, president and chief executive officer of Mt. Auburn Hospital, was assigned to lead the effort across the 6 hospitals. She retained the author of this article as a consultant. Medication reliability teams were appointed at each hospital, with nursing leaders, pharmacists, and risk managers comprising the majority of the teams' members. The medication reliability task force (all the members of all the teams) had its kick-off meeting in February 1999.

The hospital teams worked collaboratively to adopt and spread 16 "best practices" (Table 1) into routine use throughout CareGroup. These best practices had been identified by the Institute for Healthcare Improvement and the Massachusetts Coalition for the Prevention of Medical Errors to reduce adverse drug events [3]. Our strategy has been to help the team leaders at each hospital to achieve impressive local results, publicize the results to their colleagues, invite

their colleagues to learn rapid-cycle improvement techniques (eg, plan-do-study-act [PDSA]), and have the colleagues lead PDSA cycles themselves. A description of the overall project has been published [4].

Results of the process changes are being tracked. When a specific, measured, positive effect on patient safety is realized, we sound a "Gong!"—an electronic message that announces the improvement to all participants in the CareGroup hospital medication safety improvement project. The Gong! celebrates and publicizes the change and encourages other hospitals to replicate it. The subjects of 6 Gong! messages are described in this paper.

## Case Studies

### Safer Use of Epidural Medication at BIDMC

**Background.** Epidural medications provide good pain relief and conscious sedation with few side effects; however, they pose a high risk, as they do not go through the liver and are not naturally detoxified. Epidural medications are delivered by pumps. Over the years, BIDMC had bought different pumps at different times from different vendors.

A review of past incidents revealed a number of pump-related errors and near-misses. Root cause analysis suggested that the multiplicity of pumps was a contributing factor. On an orthopedic floor, for example, one nurse had 3 patients on 3 different pumps. Further, there was no standardized labeling of the epidural mixture by pharmacy and anesthesia; it could be difficult for the nurse to verify that a particular mix was the one that the physician had ordered. In addition, some pumps could not be pre-programmed, and not all nurses had received inservice training on how to use them.

**Improvement.** Previously, BIDMC had improved the safety of patient-controlled analgesia by standardizing pumps and concentrations and educating staff. A similar approach was used to improve the safety of epidural medication. Changes included use of a preprinted order sheet, standard concentrations, and a standard epidural pump; inservice training and a competency exam; a resource nurse on call for questions and teaching in the moment; and a review of all labeling and mixing processes.

*From Melior Consulting, Needham, MA.*

**Table 1.** 16 Best Practices for Reducing Medication Errors

Ordering	<ul style="list-style-type: none"> <li>Chemotherapy protocols and preprinted orders</li> <li>Weight-based heparin protocol</li> <li>Enforcement of standardized prescribing</li> <li>ED-condition management protocols</li> <li>Critical pathways for complicated care</li> </ul>
Dispensing	<ul style="list-style-type: none"> <li>Computerized drug profiling</li> <li>Unit dosing</li> <li>Pharmacy-based admixture of IV solutions</li> <li>Warning labels for look-alike/sound-alike drugs</li> <li>Pharmacist at unit, on rounds</li> <li>24-hour-a-day pharmacy service availability</li> </ul>
Administration	<ul style="list-style-type: none"> <li>Remove KCl concentrates from all units</li> <li>Patient partnering</li> <li>Colored patient allergy wristbands</li> <li>Limited number of dosages and pump types for IV solutions</li> <li>Maximum 12-hour shifts for all nursing personnel</li> </ul>
Reporting	<ul style="list-style-type: none"> <li>Nonpunitive error reporting*</li> </ul>

ED = emergency department.

\*Best practice number 17 was added later.

The preprinted order sheet was developed by patient care services, pharmacy, and anesthesia pain management experts. It was relatively easy to obtain agreement on what the standard concentration should be for most patients. For difficult pain patients, however, it was difficult to achieve a consensus among the pain management clinicians. They sought to retain the ability to tailor concentrations, eg, using 0.1% versus 1% bupivacaine or modifying an order 30 minutes later by a half of 1%. The pharmacists won their consent by warning them that different concentrations could result in errors.

Getting authorization for the capital expense to purchase pumps was also a challenge but was approved at the level of the vice president for patient care services based on the incidents that had occurred. Another challenge lay in the logistics of training all 1200 nurses on 3 shifts, including week-ends, while ensuring that patients had excellent coverage. A clinical nurse specialist managed the effort. Initially, the vendor trained one or 2 in-house nurses on each floor to serve as inservice trainers. Inservice training took place, and nurses were required to demonstrate competency in using the pump. All newly hired nurses are now also required to demonstrate competency.

**Results.** From an initial error reporting rate of 1 incident

every 62 days, since the changes were introduced the rate has dropped to 1 incident every 94 days, a 52% reduction. The improvement is even more dramatic if we exclude the "transition" period, ie, the first month the changes were in effect. After the first month, a single incident did not occur for 373 days.

**Success factors.** Key success factors included the use of a multidisciplinary approach in the development of the preprinted orders and the review of data based on local incidents (as opposed to hearing about incidents that had occurred in other settings and locales).

### Reduced Need for Intubation and ICU Care in Acute Alcohol Withdrawal at Deaconess-Glover

**Background.** The Deaconess-Glover hospital team noticed that 4 patients had experienced delirium tremens in a 2-month period, and that 2 of these patients had required intubation and treatment in the intensive care unit (ICU).

**Improvement.** The team developed a protocol to provide guidance for clinical staff when treating a patient at risk for or experiencing acute alcohol withdrawal (available for free download at [www.meliiorconsulting.com](http://www.meliiorconsulting.com)). It was signed into policy in August 2000 and was implemented promptly.

**Results.** By November 2000, at least 6 patients had been treated with the protocol and none had required intubation or treatment in the ICU. Other hospitals in CareGroup have since adopted this protocol.

**Success factors.** A standard procedure was implemented by staff committed to improving care.

### Improved Allergy Alerts at Mt. Auburn

**Background.** The pharmacy manager at Mt. Auburn Hospital noticed that a patient incurred an allergic reaction (angioedema) after receiving a drug despite the notation of an allergy in the Meditech pharmacy computer system. Upon investigation, it was learned that the nurse had correctly documented the allergy, and the pharmacy technician had entered the allergy into Meditech; however, the technician had limited the inputted information to a single, specific medication rather than setting an alarm for that class of medications.

This incident accelerated the movement to improve allergy documentation in Meditech. Several barriers were discovered. Pharmacy staff did not believe that the allergy information was being used anywhere, as they were unaware that the computer automatically flagged documented allergies upon entry of an order into Meditech. Technicians did not know the consequence of selecting among the 3 coding options

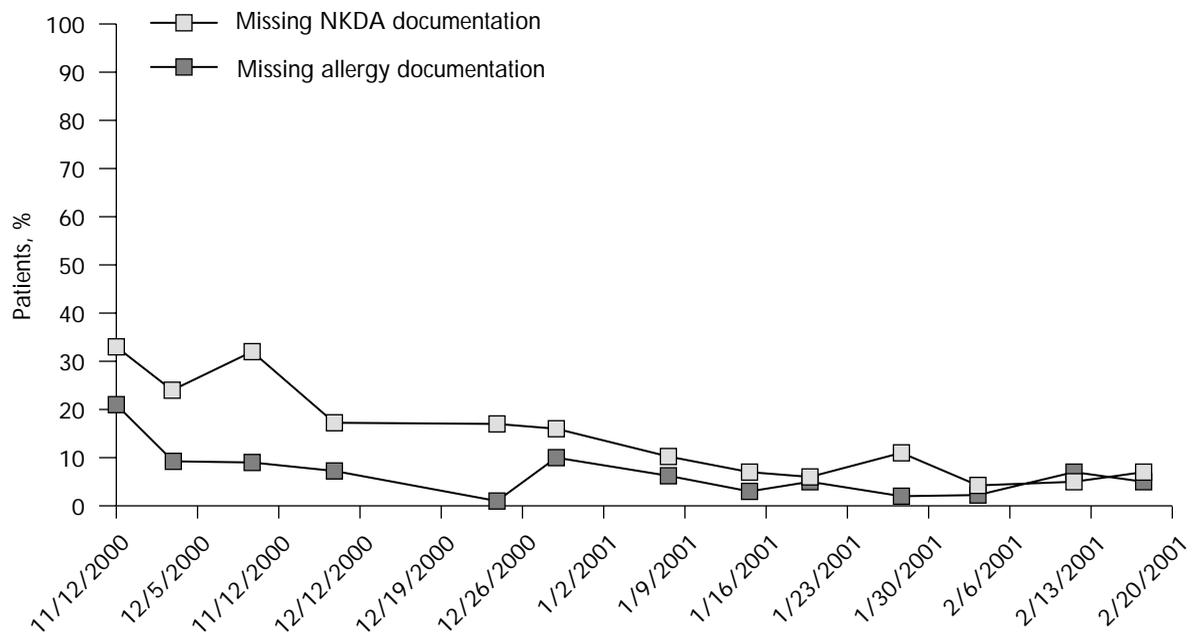


Figure 1. Computer documentation of allergies at Mt. Auburn. NKDA = no known drug allergy.

(class, generic, or ingredient). There were numerous false alarms triggered by designating an ingredient or medication allergy as an allergy to an entire class of medications. Complicating matters, documentation for individual patients was inconsistent. For example, a physician might note that a patient had an allergy, but the nurse would document “NKDA” (no known drug allergy).

**Improvement.** The pharmacy manager educated the technicians on how to correctly enter allergies into Meditech, using examples to illustrate the consequence of selecting a particular code. For example, when a codeine allergy is coded as generic, no flag appears when Tylenol with codeine is ordered. He also taught staff how to use the descriptor field for free text, eg, to add notes about nausea or vomiting.

The pharmacy manager calculated the rate of documentation weekly and plotted the data on a wall chart that hung in the pharmacy (Figure 1). He discussed improvement efforts at full departmental staff meetings, describing progress and noting setbacks.

**Results.** Documentation improved by 78%. As a result, more warning signals appear to pharmacists as they enter orders. The pharmacists’ rate of interventions and clarifications of orders rose from about 8 per month in July/August 2000 to about 46 per month in January/February 2001.

**Success factors.** Two factors were key: teaching the staff how

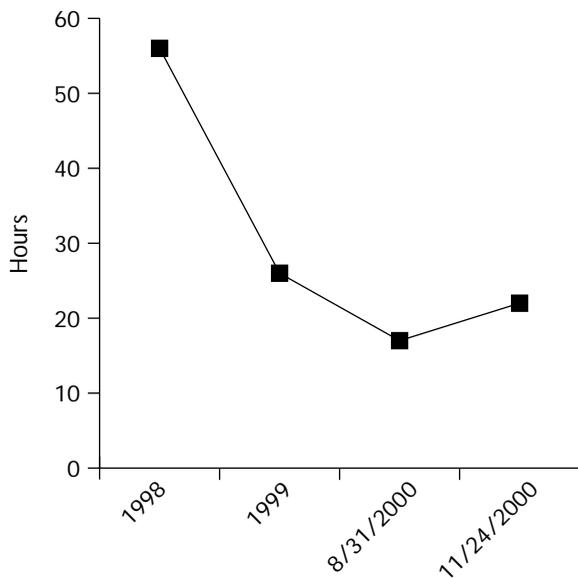
the inputting of accurate allergy information affected the safety net and providing weekly feedback and reinforcement.

**Faster Therapeutic Anticoagulation with Heparin at New England Baptist**

**Background.** Heparin is an anticoagulant widely used for the treatment and prevention of thromboembolic disease. Guidelines recommend that patients achieve therapeutic anticoagulation within the first 24 hours therapy to decrease the risk of further embolic events. Use of a weight-based protocol for unfractionated heparin dosing has been shown to improve rates of therapeutic anticoagulation within 24 hours and was one of the 16 best practices adopted by medication safety task force. Since 1998, the Baptist had been using a clinical and weight-based protocol.

**Improvement.** The team introduced a weight-based protocol, and doctors and nurses were instructed on its use. The pharmacy established a standard heparin concentration of 100 U/mL. The weight-based form entered routine use in mid-June 2000.

**Results.** By early November, the new protocol was being used 50% of the time, and the time to therapeutic anticoagulation had dropped to 17 hours (Figure 2). It should be noted that in 2000, the hospital had made a shift to using low-molecular-weight heparin instead of unfractionated heparin.



**Figure 2.** Average time to therapeutic anticoagulation with heparin at New England Baptist.

**Success factors.** The pharmacy director attributed the success to 3 key factors. First, the group that developed the order form included physicians from 3 disciplines—cardiology, orthopedics, and hematology. The earlier order form had been developed by a single hematologist. Second, a physician champion—a member of the pharmacy and therapeutics committee—was helpful in firmly promoting compliance among physicians. Third, the nurses received in-depth education on the use of the protocol.

**Two Years Without an Allergy Event at Deaconess-Nashoba Background.** Use of colored allergy wristbands was another of the 16 best practices adopted by the task force. Leaders at Deaconess-Nashoba realized that existing policies and procedures pertinent to preventing allergy events were primarily focused on documentation (eg, intake sheets, medication administration records, admission orders). The practice was to highlight allergies in the documentation in red ink, but this practice was applied idiosyncratically.

**Improvement.** In the initial change cycle, during the day the pharmacist would write the allergies on the wristbands. When the pharmacy was closed, the nursing supervisor would write them. Upon a patient's admission, the pharmacist or nurse supervisor needed to remember to ask about allergies. The team conducted a round of staff and departmental meetings in the emergency, ICU, pharmacy, and patient care departments to publicize the change. The team's initial check of the effect of the change, in September 1999,

revealed that the off-shift nurses often did not write and attach the wristbands, presumably because they thought the patient had no allergies or because they forgot. The team held another round of meetings to reinforce the earlier training. In October 1999, the team collected more data, which revealed a 98% compliance rate.

In March 2000, the pharmacy began to use the Meditech system. In December, the rest of the hospital, including the admissions unit, began to use Meditech. Allergy information is routinely inputted into Meditech. Consequently, if a physician orders a medication to which the patient has a known recorded allergy, the computer notifies the pharmacist upon entry of the order into Meditech. This prompts the pharmacist to either contact the physician to change the order or override the alert.

**Results.** The changes have inexpensively prevented known incidents associated with allergies; no incident has occurred for more than 770 consecutive days.

**Success factors.** In belt-and-suspenders fashion, both the automatic allergy alerts and the wristbands eliminated the need for physicians and nurses to rely on their memories. The team's next change will be to automate the printing of the wristbands.

**Fewer Missing Medications at Deaconess-Waltham**

**Background.** Medications were occasionally missing from the patient floors at Deaconess-Waltham, for example, after a physician increased the number of tablets to be taken daily. Allegedly missing medications numbered about 40 per day. Often the medication was not truly missing; it just was elsewhere on the patient floor. It took a lot of time for the pharmacy technicians to resolve these problems and it created extra work for the nurses, who had to revisit the patient to finish administering the remainder of the medications. It was usually easier to send an additional dose, although this did not solve the problem, and patients were sometimes billed twice. The problem might recur with the same patient's medications for several days, requiring rework in the form of phone calls and medication deliveries each time. The medication safety team sought to greatly reduce the number of missing medications each day house-wide.

The team considered all the reasons that medications might be reported as missing. They asked the nurse supervisors to post signs and to urge their nurses to look before calling the pharmacy. Shortages of some medications led to the use of newer stock that were labelled differently, causing nurses to doubt whether the correct medications had been brought up. The pharmacy informed the nurses of this. Variations in the form of the dose (eg, liquid or tablet) also might lead a nurse to consider a delivered medication missing. Also,

sufficient medications might not have been sent up for a patient newly admitted at night, for example if the order had been faxed in the early evening even though it had been written at rounds in the morning. Staff were reminded to fax the orders to the pharmacy in a timely fashion.

Several barriers arose related to the computer system. First, the fill lists generated by Meditech systematically called for too few medications to be delivered. An order entered into Meditech after the 10 AM standard daily administration time would evoke only a single dose for a “qd” (daily) order, though a second dose would be needed for the 10 AM administration the next day. Similarly, orders after 10 AM with a “bid” dosing frequency would generate a list calling for 2, rather than 3, doses for the day. Second, the default par level values were too low, as they were set at zero doses rather than at 1 day of doses at current fill rates. Third, the number of doses of bulk medications to be kept on the patient floor was systematically understated, eg, for non-single use medications like inhalers. No number of dosages would appear on the fill list for such medications so none would be sent up, in the belief that sufficient medication was already on the floor.

Barriers due to human causes also appeared. A pharmacy technician might omit an order on a lengthy list of 20 or more medications. A nurse might stamp the wrong patient’s name on the order sheet. Pills were sometimes dropped, shattering them. Different unit secretaries might inconsistently flag charts with orders.

**Improvement.** The first change was to standardize deliveries to designated “in boxes” in each nurses’ station. This resolved at least 2 problems. First, a nurse on a particular patient floor might call at 8:35 AM because a medication scheduled for the “8:30 run” from the pharmacy had not yet been delivered. Indeed, it was likely en route and scheduled to arrive within a few minutes. Pharmacists regarded the time of the run as the departure time from the pharmacy, while the nurses had always assumed the time referred to its arrival time on the patient floor. The confusion was cleared up, and arrival times were arranged so as to emulate a bus schedule and publicized. This change also reduced the likelihood that “missing” medications might actually be placed in an unexpected location on the patient floor, eg, directly into the refrigerator or onto the medication cart.

Other changes concerned special labeling and packaging for split medications (where pills of different doses are to be combined in a single administration) and unit-dose medications that do not match the dose prescribed (eg, because a pill needs to be halved to provide 2 separate doses). Another change was to provide the nurses with a simple form they could fax to report missing medications. This missing dose slip gave the pharmacy a paper trail that allowed for more

efficient trouble-shooting and better identification of trends and reasons. An additional change was to assign a pharmacist to each patient floor.

**Results.** As a result of the changes, the number of incidents fell by 117%, from 1 every 6000 doses to 1 every 13,000 doses. Evidence of the improvement could be seen from the times recorded on the medication administration record: more patients received their medications on time. The pharmacy experienced fewer distracting phone calls from the patient floors and fewer repeated faxes of orders, easing their work.

**Success factors.** The blame-free collection and use of data on types and causes of missing medications showed the nurses and pharmacists that missing medications were their own joint creation. With guidance, they saw the actions that were contributing to the problem and took responsibility for improving their operations.

## Discussion

These improvements in the ordering, dispensing, and administering of medications reduced errors and may have reduced patient injuries. They generally capitalized on existing technologies. Indeed, costs were negligible, with the exception of the epidural medication improvement. Currently, almost three fourths of the the 16 best practices are in routine use in the hospitals, and 21 specific measured improvements in medication safety have been achieved. An account of the first 6 improvements has been previously published [5]. The work was awarded the first Premier Award for Quality in December 2001.

Two factors played an important role in all of the improvement projects: education and forcing functions. Teams educated relevant clinicians, both on the need for the change and the mechanics of the change itself. Education alone may have been sufficient to catch certain near-misses. Forcing functions, eg, automatic electronic alerts, may have helped in catching other near-misses. These process changes reinforced the safety nets already in place.

There are some limitations to our approach to measurement. We have not measured uniformly; measures that are accurate, valid, and inexpensive are largely unavailable. We have used measures that are circumscribed, local, and inexpensive (**Table 2**). In 2 of the projects, we measured improvement by change in the number of filed incident reports; incident reports are known to be subjective and to underrepresent the number of actual incidents [6]. In these cases, we considered whether the reduction could have been due to an unrelated simultaneous change or to clinicians who might have so wanted to believe that care was improving that they stopped reporting certain types of incidents. However, we know of no simultaneous change, and patients with allergies

**Table 2.** Methods Used to Measure Improvement

Improvement	Measure	Objectivity	Obtrusiveness of Data Collection	Time/Cost & Nature of Data Collection
Improved epidural care	Incident reports	Low	High for write-up of incident; low for subsequent collection of reports	Low; manual
Reduced intubation & ICU transfer	Tabulation of patient census	High	Low	Low
Increased allergy information	Tabulation of elements in computer database	High	Low	Low; electronic
Faster anticoagulation	Laboratory test values	High	Low	Moderate; electronic
Fewer allergic reactions	Incident reports	Low	High for write-up of incident; low for subsequent collection of reports	Low; manual
Fewer missing medications	Tallies of work slips	Moderate	Low	Low; manual

and on epidural medications are distributed widely across patient floors. It is unlikely that nurses throughout the hospital stopped writing incident reports, especially in light of the largely successful efforts by chief nursing officers and other leaders to raise incident reporting rates at the hospitals. Thus, we believe that the measures reflect actual improvement.

As this article goes to print, the CareGroup hospitals are facing financial pressures whose effects on CareGroup's structure remain unclear. The 2 largest CareGroup hospitals, BIDMC and Mt. Auburn, have installed or are in the process of installing electronic physician order entry systems. We are optimistic that physician order entry, coupled with the work of decentralized hospital teams, will continue to greatly improve patient safety.

*Note: "Our" and "we" in this article denote the author and Dr. Clough in the context of strategy and denote the author and team members in the context of the work done by the teams.*

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