

# Safety Innovations

**Safeguarding Patients  
With Surveillance Monitoring**

**The Dartmouth-Hitchcock  
Medical Center Experience**

### Acknowledgements:

**Andreas Taenzer, MD, MS**

Assistant professor of anesthesiology and pediatrics  
The Geisel School of Medicine at Dartmouth and Dartmouth-Hitchcock Medical Center.

**Jean Avery, MBA, RN,**

Senior manager, Office of Policy Support  
Dartmouth-Hitchcock Medical Center

**Nancy Karon, BSN, RN, ONC**

Nurse Manager  
Dartmouth-Hitchcock Medical Center

**Susan McGrath, MS, PhD**

Associate professor at the Thayer Engineering School  
Dartmouth College and Director, Value Performance, Measurement and Patient Safety  
Dartmouth-Hitchcock Medical Center

### About the Healthcare Technology Safety Institute (HTSI)

Founded within the AAMI Foundation, the 501(c)(3) charitable arm of AAMI, the HTSI is a community of leaders throughout the healthcare system that are dedicated to one common vision, "No patient will be harmed by medical technology."

HTSI's mission is "To engage the entire healthcare community in multi-disciplinary safety initiatives that strengthen the development, management, and use of medical technology for improved patient outcomes." HTSI engages the healthcare community in research, education, consensus, and partnerships related to the challenges facing healthcare technology industries, regulatory and accrediting bodies, clinicians, caregivers, and patients.

#### ALARM CONDITION

State of the ALARM SYSTEM when it has determined that a potential or actual HAZARD exists

NOTE 1 An ALARM CONDITION can be invalid, i.e. a FALSE POSITIVE ALARM CONDITION.

NOTE 2 An ALARM CONDITION can be missed, i.e. a FALSE NEGATIVE ALARM CONDITION.

#### ALARM SIGNAL

Type of signal generated by the ALARM SYSTEM to indicate the presence (or occurrence) of an ALARM CONDITION

From IEC 60601-1-8:2006, Medical electrical equipment – Part 1-8: General requirements for basic safety and essential performance – Collateral Standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems

#### Permission to Copy

We encourage you to share this paper with your colleagues. You may freely reproduce this publication for educational purposes only, provided that proper attribution is made as follows: *Copied with the permission of the AAMI Foundation and the Healthcare Technology Safety Institute.* This publication may not be copied in part or in whole for commercial use.

*The views expressed in this publication do not represent the views of the AAMI Foundation or HTSI. The work of the AAMI Foundation is intended to be a helpful resource for healthcare delivery organizations, so that every organization does not have to reinvent the wheel or start their technology management work from scratch. It does not constitute legal, regulatory, operational, or procedural advice, nor does it constitute a standard of care. It is essential that each healthcare delivery organization assess the material in the context of its own organizational needs, culture, technology, and priorities.*

# Safeguarding Patients with Surveillance Monitoring

## *The Dartmouth-Hitchcock Medical Center Experience*

### At a Glance

**Subject:** Dartmouth-Hitchcock Medical Center

**Location:** Headquartered in Lebanon, NH, with six regional locations

### Introduction

A series of adverse events led clinicians and researchers at Dartmouth-Hitchcock Medical Center to a humbling conclusion: Healthcare professionals were handicapped by their limited ability to detect signs of patient deterioration and to predict which patients are at risk for adverse events in the first place. Dartmouth-Hitchcock responded with stopgap measures to safeguard patients, including double checks of opioid administration, smart patient-controlled analgesia (PCA) pumps, and rapid response teams.

Then, the medical center seized on new technology to pilot and study surveillance monitoring, first with a high-risk patient population and then system-wide, with positive results. Today, clinicians depend on the universal surveillance monitoring system to improve the quality of patient care in their daily practice.

### The Challenge

Eight years ago, Dartmouth-Hitchcock had a series of adverse events in postsurgical settings in which patients received opioids via PCA pumps. In the aftermath, the institution conducted a failure mode and effects analysis (FMEA)—a step-by-step approach for identifying possible failures or errors and

studying their potential consequences.

FMEA revealed that the events at Dartmouth-Hitchcock were textbook cases of failure-to-rescue (FTR), defined as hospital deaths after adverse events. Beginning in the 1980s, research has consistently identified two major contributing factors to FTR events:

1. **Unrecognized deterioration.** “The culmination of retrospective chart review of those patients [who experienced adverse events] showed that the vast majority had signs of physiological deterioration in the six to eight hours prior to the event,” says Andreas Taenzer, MD, MS, Assistant Professor of Anesthesiology and Pediatrics, The Geisel School of Medicine at Dartmouth and Dartmouth-Hitchcock Medical Center. Adverse events range from respiratory depression to cardiopulmonary arrests. “The nurses were checking vital signs every four or every six hours.

*“It’s not just about technology, it’s about patient outcomes.”*  
— Jean Avery, MBA, RN, senior manager, Office of Policy Support, Dartmouth-Hitchcock Medical Center

The timeframe between those checks was just too long to pick up on trends and deterioration.”

*“Even if you know a patient had an adverse event, and you look at their risk factors, even in retrospect, for only 50 percent of those patients you would say, ‘Well, we really should have known’ or ‘we really should have monitored that patient.’ In the other 50 percent, even if they would come in again, you wouldn’t monitor them specifically. It’s as good as a coin toss.”*

*—Andreas Taenzer, MD, MS, Assistant Professor of Anesthesiology and Pediatrics, The Geisel School of Medicine at Dartmouth and Dartmouth-Hitchcock Medical Center*

J. Pyke, A. Taenzer, C. Renaud, and S. McGrath. “Developing a continuous monitoring infrastructure for detection of inpatient deterioration”, *Jt Comm J Qual patient Saf.* 2012 Sep; 38 (9): 428-31, 385.

## Food for Thought

How and what is your hospital learning from failure-to-rescue events?

- 2. Unpredictable risk factors.** “Historically, as physicians as well as nurses, we had failed to correctly identify patients who were going to have adverse reactions and events,” Taenzer says. “So we had patients where we had an idea that they were at risk, like patients with sleep apnea or patients on oxygen, and we would individually monitor those patients postoperatively on the floor. And yet other patients that we didn’t identify correctly had adverse events.”

“If you look at the literature and retrospective chart reviews, that seems to be a common problem,” Taenzer adds. “Even if you know a patient had an adverse event, and you look at their risk factors, even in retrospect, for only 50 percent of those

patients you would say, ‘well, we really should have known’ or ‘we really should have monitored that patient.’ In the other 50 percent, even if they would come in again, you wouldn’t monitor them specifically. It’s as good as a coin toss.”

Moreover, “if you look at it from Dartmouth-Hitchcock’s viewpoint, it was a problem related not only to opioid issues,” says Jean Avery, MBA, RN, Senior Manager, Office of Policy Support at Dartmouth-Hitchcock. “We were also seeing those close calls in other patient populations, where there was unpredictable deterioration that may not have been related to opioids.”

Like many hospitals, Dartmouth-Hitchcock had implemented a tiered approach to respond to adverse events—a code blue team for a patient in cardiopulmonary arrest, a STAT airway team for a patient that needs urgent intubation, and a Hitchcock Early Response Team (HERT) for a patient in a noncritical care area who demonstrates early signs of deterioration and crisis (Taenzer, Pyke, McGrath, & Blike, 2010).

“The idea here was that rather than follow the hierarchical cascade of the nurse paging a resident, a resident paging an attending [physician], the attending then getting another consulting service involved—that was all taking too long,” Taenzer says. “So the rapid response team provided direct intervention based on preset criteria or a nursing concern.” But the criteria that activated the rapid response team were “not reliable enough,” he says.

From the clinical perspective, the PCA pump itself was problematic as well. “The pump device, and also our ability to actually monitor patients who were receiving opioids post-surgery, was really the area where we were focusing,” Avery says.

*“In general, we were trying to address the same problem that probably every institution in North America has had, and that is that patients had adverse events while under our care.”*

*— Andreas Taenzer, MD, MS, assistant professor of anesthesiology and pediatrics, The Geisel School of Medicine at Dartmouth and Dartmouth-Hitchcock Medical Center*

“Nuisance” alarm signals, alarm fatigue, and inability to check patient conditions from a central monitoring station were among the challenges nurses identified with the existing PCA pump.

Beginning with the FMEA investigation, Dartmouth-Hitchcock pulled together a multidisciplinary team, which included patient safety experts, researchers, physicians, nurses, biomedical and human factors engineers, and information technology (IT) and information systems (IS) experts, to identify and address the challenges. They worked collaboratively with one another and with vendors to see the solutions through.

## The Solution

The idea for surveillance monitoring actually emerged fairly quickly in the aftermath of the adverse events. Surveillance monitoring is the continuous collection of routine vital signs at the bedside to identify unrecognized physiological abnormalities and trends that signal patient deterioration. Surveillance monitoring differs from more widely used condition monitoring, which is selective monitoring of patients who are believed to be at risk for adverse events based on known co-morbidities.

From the FMEA investigation and literature review, anesthesiologist George Blike, MD, Chief Quality and Value Officer at Dartmouth-Hitchcock, and the medical center’s team realized that early identification of decline in vital signs would be the key to safeguarding all patients, not just those with known conditions. And right at the outset, Blike and others believed that, given the research and the medical center’s own experiences, surveillance monitoring would be useful beyond postoperative patients on opioids.

Putting that idea into practice, however, proved more daunting.

“One of the suggestions for us at that time was to implement SpO<sub>2</sub> [oxygen saturation] monitoring technology,” says Avery, who coordinated the medical center’s multi-pronged solution to adverse events.

Nurses in postoperative units, however, deemed the pulse oximetry technology available at that time more burdensome than helpful. “The feedback we received from staff nurses was that the current state of the pulse oximetry monitors was such that, if we put those on every patient in a unit where they’re mostly postoperative patients, a nurse could potentially have five postoperative patients at any given time on opioids,” Avery says. “The noise factor from the nuisance [alarm signals] from the current technology would be such that we wouldn’t achieve the certain benefit that we thought we would.”

## Stopgap Measures

Absent a viable technology solution for surveillance monitoring, Dartmouth-Hitchcock initially turned to the best practices it had identified to improve care for postsurgical patients receiving opioids. To prevent adverse incidents, for example, clinicians double-checked one another on opioid administration and delivery via the PCA pumps.

The medical center then deployed Abbott smart PCA pumps to ameliorate some of the drawbacks of the older pumps—a step taken to safeguard patients prior to the implementation of surveillance monitoring. (At the time, direct integration of end-tidal CO<sub>2</sub> or SpO<sub>2</sub> monitoring into the PCA module was not available.) “The core team of IT, IS, engineering, purchasing, quality, and some members of the nursing team had worked together on numerous projects over the course of probably five or six years,” Avery says, including the evaluation, selection, and implementation of large-volume infusion devices. “The team had really formed a very strong relationship.”

During those projects, the team had come to understand that implementing more advanced, IT-reliant medical equipment systems required this

**Surveillance monitoring** is the continuous collection of routine vital signs at the bedside to identify unrecognized physiological abnormalities and trends that signal patient deterioration.

*The team had come to understand that implementing more advanced, IT-reliant medical equipment systems required a multidisciplinary perspective.*

multidisciplinary perspective. “What we’re seeing in pretty much all of the equipment that’s appearing in the patient environment now is that it’s no longer just a piece of equipment owned by nursing,” she says. “For example, infusion devices used to be owned by nursing. Nursing purchased them, nursing implemented them, nursing managed them. Pharmacy had very little to do with them because the older infusion devices didn’t have drug libraries like they do now. Engineering might have been the only other one of those divisions that would have been involved because they would have been doing the maintenance on them. So we’re really moving into a new era where the IT piece is part of the equipment. You’ve got to test it in a different way, you have to implement it in a different way. It involves a lot more systems.”

A systems approach proved relevant as well to the deployment of smart PCA pumps and the subsequent safety innovation of surveillance monitoring. That systems approach is a cycle of continuous improvement that includes prioritizing improvement, designing and testing change, implementing change, and continuing to measure performance, as shown in Figure 1.

## Converging Efforts Set the Stage for Research

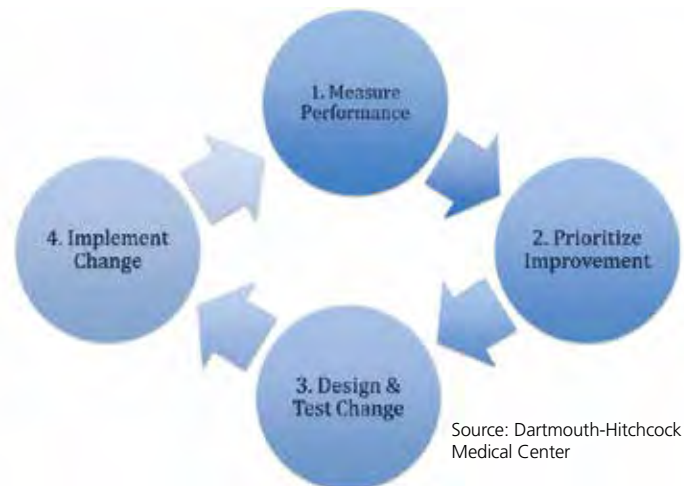
One early champion of surveillance monitoring was Susan McGrath, MS, PhD,

Director, Performance Improvement Quality, Safety, and Value Division at Dartmouth-Hitchcock. McGrath, a biomedical engineer, and Blike were long-time collaborators. They had explored surveillance monitoring at Dartmouth’s Institute for Technology Security Studies and the Institute for Health Policy & Clinical Practice, including federally funded, post-9/11 research into field triage for emergency response and decision making in military applications.

Meanwhile, as Dartmouth-Hitchcock was working to develop a viable solution to the PCA-related patient safety concerns the team had identified, Masimo Corporation had undertaken a parallel effort to improve its SpO2 monitoring technology. The breakthrough that led Dartmouth-Hitchcock to put the idea of a Surveillance System to the test began at a chance meeting at an industry conference. There, anesthesiologist Blike met James Welch, who at the time worked for Masimo. (Welch is now President of Clinical Engineering and Patient Safety at Sotera Wireless, Inc.)

“George [Blike] put all of that together and said, ‘We probably have an environment that’s ripe for us to try this,’” Avery says.

Thus began a sustained collaborative effort between Masimo and Dartmouth-Hitchcock. Working together, they identified a patient unit at the medical center that had all the elements they were looking for to conduct a robust research



**Figure 1.** The Dartmouth-Hitchcock Systems Approach to Improvement

study and to improve clinical practice, using Masimo's improved technology:

- A patient population prone to respiratory deterioration
- A strong leadership team
- Staff who were motivated to participate

That unit was 3 West, a 36-bed, medical–surgical orthopedic unit with a high-risk, mostly elderly population. Typically, patients in the unit were recovering from joint, knee, and hip replacement surgery, with a significant use of postoperative opioids.

Blike worked with McGrath; her graduate student, Joshua Pyke, BE, a human factors engineer; Klaus Christoffersen, PhD, a cognitive systems engineer with Acuite Technologies Ltd. in Toronto, who at the time was a faculty member at the Dartmouth Medical School Department of Anesthesiology; and Taenzer to design a study of the implementation and effectiveness of surveillance monitoring on 3 West.

The technology that was the centerpiece of the project was Masimo's Patient SafetyNet™, which used network communications, implemented with wired or wireless connectivity, to connect bedside pulse oximetry monitors to a server computer and a radio transmitter that notifies nurses via pagers when physiological limits are violated (Taenzer, Pyke, McGrath, & Blike, 2010). All patients on 3 West wore disposable finger probes to collect the SpO2 readings during their entire hospital stays, except when they were being directly observed by clinicians.

Why pulse oximetry? “Because if you monitor everybody all the time, the monitoring device has to be very comfortable for the patient,” Taenzer says. “If it's not comfortable, patients will not have the monitoring sensor on them all the time. They are in the hospital, at least for the orthopedic population, about three and a half days.”

“A pulse oximeter,” he says, “which is just a sticker around the finger, is relatively comfortable for them to wear, as opposed to a respiratory rate monitor that would either require a strap around the chest or an end-tidal CO2 monitor [for continuous

monitoring of exhaled CO2] that has tubing going into their nose. Imagine having to wear either for three days after surgery. We actually tested both of those devices earlier, before we started with pulse oximetry, in the recovery room alone. We found that patients' acceptance of either one of those—the chest strap or end-tidal CO2, with nasal cannula—was very low.”

To measure the effectiveness of the Surveillance System Patient SafetyNet intervention, the research team collected baseline data for 11 months before the implementation (Jan. 1 to Nov. 30, 2007) on two primary patient outcomes—rescue events and transfers to the intensive care unit. Then they collected data for 10 months of the implementation (Dec. 1, 2007, to Sept. 30, 2008). Concurrently, the same data were collected in two comparison units at Dartmouth-Hitchcock, a surgical unit specializing in urologic, gynecologic, and vascular procedures and a general surgical unit. These units used condition monitoring, but not surveillance monitoring, during the study period.

The inclusion of biomedical, human factors and cognitive systems engineering expertise on the research team is notable. The Surveillance System was designed to maximize patient and nurse acceptance, minimize false positive alarm signals, and only alert for clinically meaningful situations (actionable events) (Taenzer, Pyke, McGrath, & Blike, 2010). The research team was as interested in making sure the Surveillance System posed no undue burdens on patients and clinicians as it was in patient outcomes.

*The inclusion of biomedical, human factors, and cognitive systems engineering expertise on the research team is notable.*

## The Central Role of an Engaged Nurse Manager And 100 Percent of the Nursing Staff

Nancy Karon, BSN, RN, ONC, played a central role representing the patient and clinician perspectives during the rollout of the Surveillance System on 3 West. Karon, Nurse Manager of the unit, supported her staff throughout the implementation. She characterizes her role as:

- Listening to staff
- Engaging staff
- Educating staff
- Mentoring staff
- Problem solving with staff
- Sharing stories and results
- Celebrating success

In collaboration with Avery, Karon led discussions with some 40 nurses and 20 licensed nurse assistants (LNAs) on all shifts, starting with their basic questions: “Why us? Why 3 West? Why were we chosen?” She explained the potential benefits for them, in terms of more timely and actionable information about their patients and, thus, improved patient care and outcomes.

She also responded to their concern that the acuity rate of patients on 3 West would increase with the surveillance monitoring technology. On a unit with a 1:5 nurse-to-patient staffing ratio, nurses already had their hands full attending to patient needs. She told them, “We promise you that patients will not be forced out of the ICU to you because you

have a way to monitor them that you couldn’t do yesterday.”

Karon engaged the nursing staff in planning the installation of the surveillance monitoring equipment. Working with Pyke and Kristoffersen, and Kenneth Lee, Clinical Manager in Biomedical Engineering, they thought through the details that matter to clinicians. For example, she says, “Where do we put the equipment that’s both useful for the height of the five-foot person and the six-foot-six nurse to be able to look at the screen? Where can you put the monitors so you can look in the door of a double room and see what’s going on with both of your patients in a split second, vs. where do you put the monitor in a single room? What is the layout of the floor and the workflow that would facilitate nursing care as we roll this out?” Nursing also had input into the kind of finger probe that would be used and control over alarm thresholds and delayed notification of alarm conditions.

Nurses also had the power to pull the plug on the project. Surveyed six weeks into the pilot on whether or not 3 West should continue with surveillance monitoring, “One hundred percent of the staff said, ‘do not get rid of this,’” Karon says. “‘Of anything you’ve ever given me, this is the best tool that I have. It’s my eyes and ears.’”

*“One hundred percent of the staff said, ‘do not get rid of this. Of anything you’ve ever given me, this is the best tool that I have. It’s my eyes and ears.’”*

*— Nancy Karon, nurse manager,  
3 West Unit, Dartmouth-  
Hitchcock Medical Center*



## Implementing the System— And Responding with Adjustments

Implementing the Surveillance System on 3 West required planning and coordination among the research team, physicians, and nurses; the biomedical, IT and IS departments; and Masimo representatives. At every step of the way, they encountered challenges that prompted adjustments to their monitoring, technology, and education plans.

**Calibrating the parameters of monitored variables.** Dartmouth-Hitchcock decided to track two variables, oxygen saturation and heart rate, with surveillance monitoring. The team negotiated alarm condition thresholds, alarm signal notification delay, and a three-tiered system for alarm parameter adjustments, as shown in Table 1. These parameters evolved over time and with experience.

“With oxygen saturation, you only need one alarm limit, because higher oxygen saturation is almost always good,” Taenzer says. “So you don’t need an upper limit.” In operating room, sedation, or selective condition monitoring, that low threshold for oxygen saturation is typically set at 93 percent (Taenzer, Pyke, McGrath, & Blike, 2010).

Based on a month of observed physiology, Dartmouth-Hitchcock realized that 3 West would be plagued with frequent, inactionable alarm signals at that level. So the team settled on an oxygen saturation alarm parameter of less than 80 percent, to be sensitive and specific enough to find adverse events that required intervention—without burdening nurses with alarm fatigue.

“For example, there are frequently patients who have periodic desaturations as part of their sleep pattern—some mild sleep apnea,” Taenzer explains. “So they desaturate periodically overnight and then they come back up. We did not want to know about just brief desaturations.”

“We found a notification delay of 15 seconds at the bedside and a further 15 seconds prior to nurse notification work well,” he says. “These delays limit notifications for alarm signals that we did not want

to know about. For example, if you pinch your finger or clench your fist or lift up a cup or hold your toothbrush for a brief period of time, you have a desaturation not based on the fact that your oxygen levels go down, but the perfusion to your finger goes down and the probe doesn’t read correctly. So there are many self-limiting processes that are of short duration of 30 seconds. We didn’t want those to signal alarms because then we would have problems with higher alarm signal rates and alarm fatigue to the nurses.”

“Initially, there was no delay in our alarm signal notification to the nurse,” Karon adds. “It took less than 24 hours for us to say we need a sustained delay. This was purely from staff feedback to make this a sustainable system that would work for them.”

**Doubling down on training.** The project team developed a comprehensive training program for all nurses on 3 West. The training included a motivational discussion of the problem of unrecognized patient deterioration led by Blike, in-service training on Patient SafetyNet provided by Masimo, and a description of the alarm threshold policy. All 60 nurses and LNAs were required to participate in the training.

Once the Surveillance System went live on 3 West, Karon, Avery, and Lee led daily clinical rounds for two weeks to help nurses become comfortable with the clinical and equipment aspects of the system. The clinical rounds continued less frequently thereafter.

“We had learned through our infusion device implementation just prior to this that getting in early and engaging the staff was important in terms of being able to prevent bad habits, if you will,” Avery says. “If we identified that nurses had a potential problem or issue with one aspect of the system, we jumped right in and tried to understand that and make improvements to it. Was it education that was needed or was it design in the system that was needed? Was it probe placement? Was it the paging system? Was it the actual admission/discharge into the

*With oxygen saturation, you only need one alarm limit, because higher oxygen saturation is almost always good.*

Alarm Thresholds	
SpO <sub>2</sub> (oxygen saturation)	< 80%
Heart rate	< 50 and > 140 beats per minute
Notification Delay	
30 seconds	(15-second audio alarm signal delay at bedside, plus 15-second delay for pager annunciation)
Three-Tiered System for Alarm Parameter Adjustments	
1. Standard setting	
2. Bracketed adjustment (± 10% of baseline) by nursing staff	
3. Physician-ordered settings	

**Table 1.** Alarm Thresholds, Notification Delay, and a Three-Tiered System for Alarm Parameter Adjustments

Source: Taenzer, Pyke, McGrath, & Blike, 2010

admission station? What was it that we needed to do?”

For example, clinical leaders realized early on in the 3 West pilot that they had been overconfident about staff capacity to use the Masimo paging devices. “We took it sort of lightly,” Karon says. “Staff know how to text, they’re using cellphones, they’re using computers.” But when nurses had trouble using the pagers—relatively complex devices for nurses who had never used pagers before—the team brought Masimo back to provide more training.

The clinical rounds focused on “simple things,” Karon says. “If I’m left-handed and my IV is on my right hand, don’t put my probe on my left hand—unless my right hand is broken and too swollen to give good perfusion. On the other hand, if it’s elevated and not swollen, that’s the perfect hand to put it on because that hand is not going to be used and then we won’t have as many false alarms. Invariably, anesthesia sends the probe out on the index finger. That’s the worst finger you can put it on. So when the patient gets out here, we need to transition to a different finger. Put it on the fourth or fifth finger where you’re going to get better compliance from the patient”—and fewer alarm signals.

**“Aha” moments.** The clinical rounds went beyond the mechanics of using the technology correctly. “Nancy [Karon] is an amazing leader,” Avery says. “She taught as we were doing rounds. If there was an opportunity to

learn why a person might be potentially deteriorating, she helped problem solve with the nurse, triggering them to think through the problem. It’s not just about technology, it’s about patient outcomes.”

By taking advantage of these teachable moments, the clinical leaders began to see nurses using Surveillance System as a powerful tool that helped them improve patient care. Avery shared two moments in particular:

- Within the first few weeks of implementation, a nurse noticed that an elderly, postsurgical patient who did not have an order for oxygen was becoming increasingly confused and desaturated. “So the [oxygen saturation] rates were showing 98 percent, 96 percent, 94 percent, then 90 percent,” Avery says. The nurse called the doctor, they discussed the symptoms, and they started the patient back on oxygen. The patient’s confusion cleared. “So for me, that was an aha moment in a nurse using the system in a different way”—even before an alarm signal notification was issued.
- A patient complained to a nurse about the frequency of the alarm signals from the monitoring equipment. “The nurse said, ‘that’s because you’re postoperative and you’re not deep breathing. What I want you to do is when the alarm goes off, use your incentive spirometer,’ which is a breathing device that helps the patient expectorate and take deep breaths

and expand the lungs and prevent postoperative pneumonia.” The patient followed these instructions, brought up the oxygen saturation rate, and experienced no further problems.

“For me that was another aha moment,” Avery says. Nurses were using the system to help them problem-solve other issues, not just to prevent patient deterioration, but to intervene even before they began to trend downward or miss parameters.

Karon shared stories like these and, as it became available, outcome data with the nursing staff to reinforce the ways in which surveillance monitoring could improve patient care.

## The Results

The 10-month pilot of surveillance monitoring on Dartmouth-Hitchcock’s 3 West unit achieved the anticipated results:

- Fewer rescue events
- Fewer transfers to the ICU for escalated care

Rescue events decreased from 3.5 per 1,000 patient days before the implementation to 1.2 per 1,000 patients afterwards. “The rescue events consist primarily of activation of our rapid response team as well as cardiopulmonary arrests and respiratory arrests,” Taenzer says. Table 2 shows the rescue events for 3 West and the two comparison units.

ICU transfers decreased from 5.6 per 1,000 patient days before the implementation to 2.9 per 1,000 patients afterwards. That amounts to approximately 150 fewer days that patients spent in ICU beds as a result of transfers from the medical–surgical unit due to worsening conditions. Table 3 shows the ICU transfers for 3 West and the two comparison units.

In addition to these two primary outcomes, Dartmouth-Hitchcock documented high patient acceptance of the surveillance monitoring, with 98.2 percent of patients wearing the finger probes throughout their stays. The number of alarm notifications averaged four per patient per day, or two per 12-hour nursing shift (Taenzer, Pyke, McGrath, & Blike, 2010).

	Rescues Before Surveillance Monitoring	Rescues After Surveillance Monitoring	P Value
<b>3 West Pilot Unit</b>	3.4 ± 2.2	1.2 ± 0.9	0.01
<b>Comparison Unit 1</b>	2.0 ± 0.9	1.3 ± 1.7	0.5
<b>Comparison Unit 2</b>	2.7 ± 0.8	3.4 ± 0.7	0.5

**Table 2.** Rescue Events per 1,000 Patient Days per Month

Source: Taenzer, Pyke, McGrath, & Blike, 2010

Equally important, clinical acceptance of surveillance monitoring was strong. “The technology had advanced, it was there,” Taenzer says. “The key to success was that the technology was matched with a culture of caring, the strong support of all involved stakeholders, and the conviction that we had to change. I think we were able to do that because of the first-rate relationships between different services, going from nursing to information technology to physicians and administrators—everybody was involved and participated.”

## Ongoing Improvements and Innovation

Based on its results, Dartmouth-Hitchcock expanded surveillance monitoring to

### Food for thought

It’s not just about technology, it’s about patient outcomes.

## Critical Elements for Success

- Listen (engage staff, seek feedback, hold team meetings)
- Train and educate (make daily rounds, provide leadership)
- Communicate findings and share insights
- Make timely adjustments to the system and process
- Measure and provide feedback
- Provide pager education
- Minimize alarm signals with delayed notification, proper probe placement, parameter adjustment
- Celebrate success

two additional surgical units in 2009, the remainder of adult medical–surgical units in 2010, and to the pediatric and adolescent unit in 2012.

Even so, the Surveillance System is not yet completely wireless because pulse oximeter finger probes are not yet wireless. The patient is attached via a six-foot cable to a bedside monitor, which sends physiologic data to a central workstation that then sends pager notification to nurses. Therefore, patients are not monitored when ambulating.

The medical center continues to collect data on the impact. “What we have found consistently in our units is that the number of rescue events went down,” Taenzer says. “That is because we detect events early and intervene early enough that we don’t even need to activate the rescue team.”

The team also discovered—somewhat to its surprise—that the overall distributions of oxygen saturation levels and heart rates among adult patients are very homogeneous (Taenzer & Blike, 2012). This discovery validated that these are appropriate variables to monitor. For pediatric patient monitoring, heart rates parameters are adjusted for different age brackets, but the

oxygen saturation parameters are the same as for adults.

Dartmouth-Hitchcock continues to look for innovative approaches to surveillance monitoring. “Some of the things that we’re looking at moving forward are how we might be able to optimize the system for different populations,” McGrath says. “We’re looking at other parameters that can be used with the system, such as respiration and other vital signs, and smart alarms—how we might be able to improve on the threshold rates alarming. And, as the system is in place over a period of years, does it get used in the same ways by the nursing staff in different units? And how can we maintain the education and use of the system at an optimum level?”

Finally, the medical center has strengthened its education and training program for surveillance monitoring, based on its experiences with 3 West and other units. The program is now divided into three parts:

- **Background**—An online slide presentation that explains the rationale for surveillance monitoring, defines surveillance and condition monitoring, and explains how to use the system as a problem-solving tool. Nurses can access

*“The key to success was that the technology was matched with a culture of caring, the strong support of all involved stakeholders, and the conviction that we had to change.”*

*— Andreas Taenzer, MD, MS, assistant professor of anesthesiology and pediatrics, The Geisel School of Medicine at Dartmouth and Dartmouth-Hitchcock Medical Center*

For their achievements, Blike and Welch won the 2011 AAMI Foundation/Institute for Technology in Health Care *Clinical Application Award* (In 2013, this award was renamed as the “*Clinical Solutions*” award). The award is given annually to individuals who have applied innovative clinical engineering practices or principles to solve significant patient care problems. Dartmouth-Hitchcock also won the 2009 ECRI Institute Health Devices Achievement Award for excellence in health technology management.

	ICU Transfers Before Surveillance Monitoring	ICU Transfers After Surveillance Monitoring	P Value
3 West Pilot Unit	5.6 ± 2.8	2.9 ± 2.0	0.02
Comparison Unit 1	5.7 ± 1.6	5.2 ± 1.3	0.8
Comparison Unit 2	15.0 ± 5.7	12.4 ± 3.7	0.3

**Table 3.** ICU Transfers per 1,000 Patient Days per Month

Source: Taenzer, Pyke, McGrath, & Blike, 2010

this information on their own, anytime. They have to pass a competency exam on this content before they move to hands-on training on the equipment.

- **Pager training**—Hands-on training to use the pager for surveillance monitoring
- **System training**—Hands-on training to use the Surveillance System, including the patient probes, room monitors, and central monitors, and how to admit and discharge monitored patients

## Implementing Surveillance Monitoring in Your Hospital

The Dartmouth-Hitchcock team believes that surveillance monitoring is a viable and replicable solution for any hospital that faces the universal challenges of limited ability to detect signs of patient deterioration in time to head it off and to predict which patients are at risk for adverse events in the first place.

In fact, Taenzer believes surveillance monitoring is even more critical for hospitals that do not have rapid response teams at the ready when adverse events occur. A research study does not have to be part of the implementation.

### For Further Reading

1. Pyke, J., Taenzer, A.H., Renaud, C.E., & McGrath, S.P. (September 2012). Developing a continuous monitoring infrastructure for detection of inpatient deterioration. *The Joint Commission Journal on Quality and Patient Safety*, 38(9): 428–31, 385.
2. Taenzer, A.H., & Blike, G.T. (Spring–Summer 2012). Postoperative monitoring—The Dartmouth experience. *ASPF Newsletter*, 27(1), 1, 3–4, 21.
3. Taenzer, A.H., Pyke, J.B., McGrath, S.P., & Blike, G.T. (February 2010). Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: A before-and-after concurrence study. *Anesthesiology*, 112(2), 282–287.
4. Taenzer, A.H., Pyke, J.B., & McGrath, S. P. (August 2011). A review of current and emerging approaches to address failure-to-rescue. *Anesthesiology*, 115(2), 421–431.

## Here are some tips for getting started:

- Bring together a multidisciplinary team to design, test, and implement the project
- Collect baseline data on patient outcomes
- Determine patient population(s) to monitor
- Evaluate and select a patient surveillance system
- Develop alarm thresholds, notification delay time, and a system for alarm parameter adjustments
- Identify a unit for piloting the system
- Educate, train, and listen to staff
- Implement the system
- Monitor patient outcomes
- Communicate progress
- Scale up

### Contact Us

Has your healthcare organization implemented any of the strategies discussed in this publication?

Do you know of a healthcare facility that has dealt with a technology-related issue and has a story to share?

If so, we would love to hear from you! Please email [slombardi@aami.org](mailto:slombardi@aami.org).

#### Contact Information:

AAMI Foundation  
4301 N. Fairfax Drive, Suite 301  
Arlington, VA 22203  
Phone: +1-703-525-4890  
Fax: +1-703-276-0793  
Email: [slombardi@aami.org](mailto:slombardi@aami.org)

[www.aami.org/foundation](http://www.aami.org/foundation)

#### Contributions and Donations:

To make a tax-deductible donation, please complete the donation form at [www.aami.org/foundation/donate](http://www.aami.org/foundation/donate) and mail your check or money order to:

AAMI Foundation  
4301 N. Fairfax Drive, Suite 301  
Arlington, VA 22203-1633

