

Three Steps to Reducing Your Alarms and Improving Patient Safety

Patient monitors are designed to serve as an extension of the nurse and other clinicians for observing changes to key physiologic parameters. Monitor alarms alert caregivers to changes in the patient's condition that may indicate the need for intervention. These alarms are essential to patient safety across the healthcare continuum and in many cases, are lifesaving.

Due to the proliferation of monitors designed to provide clinicians with more physiologic information and improve patient safety, the number of alarms encountered by clinicians has risen proportionally. Studies indicate that the majority of alarms do not require a clinician intervention.ⁱⁱⁱ Clinicians overwhelmed by the sheer multitude of beeps may ignore alarms (i.e., “alarm fatigue”) sometimes with catastrophic results.ⁱⁱⁱ

ECRI, an independent, nonprofit organisation that researches the best approaches to improving the safety, quality, and cost-effectiveness of patient care, has published the Top 10 Health Technology Hazards list annually.^{iv} Alarm hazards have been on every list since 2010, and topped the list in 2012–2014.

The Joint Commission released a Sentinel Event Alert (SEA)ⁱⁱ on Medical Device Alarm Safety in Hospitals and a National Patient Safety Goal on Alarm Management.^v

The SEA stated alarm hazards are a “frequent and persistent problem” with 98 alarm-related events reported between January 2009 and June 2012—80 resulting in death and 13 in permanent loss of function.

The organisation also recognised that alarm-related injuries are significantly under-reported, and that the total number is likely much higher.

The Joint Commission cites “alarm fatigue” as the

most common contributing factor to alarm-related events. Many of the events occurred in areas with lower clinician-to-patient ratios including telemetry units, the emergency department and the intensive care unit.

What is “alarm fatigue”?

While there is not a standard definition of alarm fatigue, a 2011 summit convened by AAMI, FDA, TJC, ACCE, and ECRI Institute exploring clinical alarms concluded that:ⁱⁱⁱ

- Alarm fatigue is when a nurse or other caregiver is overwhelmed with 350 alarm conditions per patient per day.
- Alarm fatigue is when a patient can't rest with the multitude of alarm signals going off in the room.
- Alarm fatigue is when a true life-threatening event is lost in a cacophony of noise because of the multitude of devices with competing alarm signals, all trying to capture the clinician's attention, without clarity around what the clinician is supposed to do.
- Alarm fatigue is compounded by inconsistent alarm system functions (alerting, providing information, suggesting action, directing action, or taking action) or inconsistent alarm system characteristics (information provided, integration, degree of processing, prioritisation).
- Alarm fatigue is a system failure that results from technology driving processes rather than processes driving technology.

In addition to the potential hazard to patient safety from alarm fatigue, numerous alarms that don't require intervention also create disruption to the clinician's work, which has led to the term 'nuisance alarm'. These disruptions may detract from the care and oversight of other patients, consume time from a busy schedule, and cause a loss of confidence in the monitors.

Much of the discussion around alarm management centers on the development of better technology. While Covidien is committed to leadership in innovation to improve alarm management, three relatively easy steps can be taken today to significantly reduce your non-actionable alarms.

Step 1–Managing Default Alarms

The Joint Commission cited that common causes of alarms include setting the alarm thresholds “too tight,” and default alarms not adjusted to individual patient needs.^{vi,vii} When establishing a monitoring protocol for the post-operative general care floor (GCF), it is not uncommon for the facility to look to traditional monitoring environments such as the ICU for establishing default alarm settings. ICU patients are generally at a much higher acuity level where alarm thresholds are set relatively close to the patient's baseline values to provide early warning to any patient changes.

Experienced users report that alarm settings on the post-op GCF and other lower acuity areas can be set 'wider' while still providing adequate notification of significant changes in the patient's condition. In a survey of 21 experienced capnography users, alarm limits for high/low ETCO₂ and high/low respiratory rate were set differently based on the care environment being

monitored (See Table 1).^{viii*}

For example, high/low RR alarms were set at average values of 45.0 and 4.5 breaths per minute respectively on the GCF compared to 32.0 and 9.0 in the ICU. High/low ETCO₂ alarms were set at average values of 60.0 and 8.5 on the GCF compared to 50.0 and 25.0 in the ICU. Reported GCF alarm settings from this survey correspond to other reports from the literature.^{ix,x}

In a study of alarms on the medical/surgical floors of a community hospital, alarms for heart rate were reduced by more than 50% with a simple limit adjustment of high HR from 120 to 130 bpm and a 36% or 65% reduction in SpO₂ alarm load was achieved by reducing the SpO₂ limit from 90% to 85% or 80% respectively.^{xi}

A similar study on a cardiac telemetry unit found that small adjustments, including changes to the low and high HR limits, resulted in an overall reduction in audible alarms (89%) without requirement for additional resources or technology.^{xii} Staff and patient satisfaction also improved. There were no adverse events related to a missed cardiac monitoring event, and 'code blue' incidents decreased by 50%.

Customising Alarm Settings to Individual Patient Needs

Over-reliance on a standard set of default alarms for all patients ('one size fits all') may also contribute to the alarm burden. Alarm settings should be customised based on individual patients when appropriate. For example, baseline ETCO₂ and SpO₂ values for a patient with severe COPD would be significantly different than for a patient with normal lungs.

In a study of changes in alarm management in a

Table 1 – Average Capnography Alarm Limits Used by Care Environment^{viii*}

Environment	ETCO ₂ High	ETCO ₂ Low	RR High	RR Low	No Breath Delay
Procedural Sedation	52.5	23.0	24.0	6.6	17.1
Emergency Depart.	50.8	24.5	28.3	8.3	13.2
General Floor	60.0	8.5	45.0	4.5	27.5
OR-PACU	56.7	19.3	24.0	8.0	19.3
Intensive Care Unit	50.0	25.0	32.0	9.0	15.0
All	53.8	20.2	30.3	7.1	18.3

medical progressive care unit, nurses were trained to individualise patients' alarm parameter limits and levels.^{xiii} Critical monitor alarms were reduced 43% from baseline data.

In an AACN Practice Alert on alarm management, there is a recommendation to customise the alarms to meet the needs of individual patients. They recommend: "Set customised alarms within 1 hour of assuming care of a patient and as the patient's condition changes."^{xiv}

Step 2–Patient Education

Another cause of alarms is the patient removing a monitor sensor. Too often, patients aren't properly instructed about why they are being monitored. If patients are not educated and do not understand the benefit it provides, there is a greater chance that the patient will remove the interface. Experienced users report that by educating the patient and family prior to the procedure and reinforcing it during monitoring, patients are more likely to be compliant.

"Patient education is the key. A well-educated patient and family is a key to having successful compliance with using [capnography]. Once the patients and the families understand that it's being done for safety, for their safety, they're much more compliant. They don't have any issues wearing the cannulas."

– Harold Oglesby RRT, Director of Respiratory Care, St. Joseph / Candler Hospital

"We've experienced really high compliance with our patients who have been using the end tidal CO₂ monitoring. It's very rare that once we've explained how important it is, that a patient says I don't want that on my nose. Most patients do very well with it."

– Joan Kohorst, MA, RRT, Director of Infusion and Medication Administration Safety, Sisters of Mercy Health System, St. Louis, Mo.

"Patient education is the key to patient compliance. It would be ideal to educate patients prior to surgery."

–Debra Fox, RRT, Director of Respiratory Care, Wesley Medical Center, Wichita, Kansas.

"Newer nasal-oral cannulas used to measure capnography in spontaneously breathing patients are very well tolerated by children."

–Melissa Langhan, M.D., Associate Professor of Pediatrics, Yale School of Medicine, New Haven, Conn.

"Observational studies substantiate our finding that continuous monitoring by capnography is feasible in very young children."

–Jenifer R. Lightdale, M.D., MPH, Children's Hospital Boston, Mass.

Education of the patient and family is most effective when it is simple and brief. Covidien offers educational tools to assist and are available from your Covidien representative. Key points for clinicians to educate include:

- Explain that some medications that will be given can make breathing slow or shallow, and can be dangerous if not monitored. State that the monitor will alert clinicians to changes in breathing before any harm occurs.
- Let patients and family members know that alarms alert clinicians to a change in breathing. Explain that alarms can serve as a reminder to the patient (and family) of the need to take deeper breaths.
- Remind the patient that if the interface is removed for brief periods, for activities such as eating or getting out of bed, it should be replaced immediately after the activity.
- Inform patients that routine postsurgical activity, like sipping water or eating ice chips, does not interfere with ventilation monitoring. But care should be taken not to introduce liquids into the sampling ports as this may block the sample line and create an alarm.

Supplemental Covidien Materials

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Covidien Implementation Connection EDUCATION

The Microstream™ technology Education Pathway was developed to provide a specific, relevant curriculum for clinicians responsible for using CO2 monitoring with patients to help ensure the highest quality of care. This pathway is available in a number of formats to meet your needs. It includes a 1-hour video, a 1-hour audio, and a 1-hour PDF. The pathway is available in a number of formats to meet your needs. It includes a 1-hour video, a 1-hour audio, and a 1-hour PDF. The pathway is available in a number of formats to meet your needs. It includes a 1-hour video, a 1-hour audio, and a 1-hour PDF.

Online Capnography Education Recommendation Overview

Capnography Monitoring Method	Adult Care	Neonatal Care	Pre-hospital Care	Out-of-Hospital Care	Out-of-Hospital Care
Capnography Monitoring Method	•	•	•	•	•
Adult Care	•	•	•	•	•
Neonatal Care	•	•	•	•	•
Pre-hospital Care	•	•	•	•	•
Out-of-Hospital Care	•	•	•	•	•

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Capnography Education Course Listing

Preventing Alarm Fatigue

Monitor alarms are designed to alert clinicians to changes in the patient's condition that may indicate the need for intervention. These alarms are essential to patient safety across the healthcare continuum and in many cases, are lifesaving. Due to the proliferation of monitors designed to provide clinicians with more physiological information and improve patient safety, the number of alarms associated with clinical care has grown exponentially. It is estimated that 80 percent of all alarms do not require an intervention. Cannot include setting the alarm threshold "too high," adjust alarm not selected to individual patient needs, or ensure that not all alarms are applied. "Clinicians overwhelmed by the sheer volume of beeping tones (alarms) in the alarm fatigue literature with catastrophic results. The Journal Club published a series of articles" in the results of alarm fatigue that were published January 2009 to June 2010. 200 hospital patient deaths nationwide were linked to problems with alarms on patient monitors." The article discussed several specific cases, including an elderly man whose electrocardiogram (ECG) failed to flow for more than two hours without caregiver response.

The ICDL, an independent nonprofit organization that researches the best approaches to improving the safety, quality, and cost-effectiveness of patient care, has published the Top 10 Health Technology Risks for roughly one year. An alarm hazard has been on the list since 2010, and topped the list in 2012 and 2013. As a result, ICDL published additional guidance on addressing strategies for alarm management."

Joint Commission Issues Sentinel Event Alert
Most recently, The Joint Commission released a Sentinel Event Alert (SEA) on Medical Device Alarm Safety in Hospitals and a National Patient Safety Goal on Alarm Management. The Joint Commission alert stated that it is a "significant and preventable problem" with alarm-related events reported between January 2009 and June 2012 – 100 incidents in total and 119 patient lives in jeopardy. The organization also recognized that alarm-related events are significantly under-reported, and that the total number of incidents is likely much higher. The SEA notes that the U.S. Food and Drug Administration (FDA), Manufacturer and User Facility Device Experience (MAUDE), database reported 50 alarm-related patient deaths from January 2005 to June 2010, considered by industry experts to under-represent the actual number of incidents.

The Joint Commission also alerts hospitals to "the most common contributing factor" to alarm-related events. Many of the events occurred in areas with lower detection-to-patient ratios including telemetry units, the emergency department and the intensive care unit. The Joint Commission makes a number of recommendations for reducing the problem.

In Phase I (beginning January 2014), hospitals will be required to establish alarm as an organization priority and identify the most important alarms to manage based on their own operational situation.

In Phase II (beginning January 2016), hospitals will be required to identify and implement specific components of policies and procedures. Education of those in the organization about alarm response management will also be required by January 2016.

Preventing False Alarms
Reducing nuisance alarms starts with the accuracy of the monitor. A monitor providing erroneous readings will generate false alarms.

The industry-leading **Infra-Red™** technology with **CO2** technology from **COVIDIEN** is the only carbon-dioxide monitor with sophisticated algorithms that adjust quality when conditions are appropriate for passing of the compensated light, and make sure values "are not significantly affected by" noise" caused by various blood and other issues. The monitor's built-in pre-processed reading. A second filter that the technology already had in the patient's physiology requires less signal processing, preventing signal over-processing, which can mask true patient events from being displayed.

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Smart Alarm Management White Paper

Smart Alarm Management™ Integrated Algorithms

Smart Alarm Management™ Integrated Algorithms (SMAI)
Empower the clinical team with intelligent algorithms that respond to patient status and help lead to "alarm fatigue," which can result in clinically significant alarms being ignored, often with tragic results.

In response to this growing problem, the Joint Commission has released a Sentinel Event Alert and a National Patient Safety Goal on alarm management that requires hospitals to "establish alarm as an organization priority and identify the most important alarms to manage based on their own internal situation" by January 2014. The Joint Commission also stated that hospitals will be expected to develop and implement specific components of policies and procedures by January 2016.

As a market leader, Covidien is dedicated to the development of Smart Alarm Management technologies that are designed to reduce the number of nuisance alarms while alerting caregivers to clinically significant events.

Smart Alarm Management™ Integrated Algorithms (SMAI)
Think of SMAI as a "smart" alarm system that responds to patient status and help lead to "alarm fatigue," which can result in clinically significant alarms being ignored, often with tragic results.

Smart Alarm Management™ Integrated Algorithms (SMAI)
Empower the clinical team with intelligent algorithms that respond to patient status and help lead to "alarm fatigue," which can result in clinically significant alarms being ignored, often with tragic results.

Smart Alarm Management™ Integrated Algorithms (SMAI)
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Smart Alarm Management Sell Sheet

COMPARING CAPNOGRAPHY ALARM LIMITS USED IN DIFFERING CARE ENVIRONMENTS

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Introduction: Alarm settings on capnography monitors are important and have the potential to prevent extubation events and even deaths by alerting caregivers to dangerous situations such as apnea and significant changes in CO2 levels. However, excessive alarms including clinically significant alarms ("nuisance alarms" or false-positive alarms caused by artifacts) have been shown to decrease compliance in clinically significant alarms and become a threat to patient safety. As a result, many care settings are beginning to present and display monitors, potentially reducing compliance with monitoring. Recently, algorithms have been developed which have been shown to significantly reduce such clinically insignificant alarms.

Our goal was to determine the effect of alarm settings on compliance with monitoring. We conducted a study to compare capnography alarm settings commonly used between multiple care environments. Data on differing monitoring needs in each environment, alarm settings used, and other such information may be useful to new users in developing their own alarm limit protocols to address the needs of their care environment.

Methods: A survey of capnography monitors was conducted using a web portal (SurveyMonkey.com). Results for the entire group across all care environments are included in a separate paper. In this secondary analysis, data was reviewed and average and standard deviation (Mean/SD) by individual care environment.

Results: Twenty-one experimental units responded for adult applications of capnography. Responses were received from the following care environments: Average values for responses from each environment are presented below.

Table 1 - Average Capnography Alarm Limits Used by Care Environment

Environment	Response	40% Low	40% High	PCV2	RR	SB	No Break
Emergency Department	18	10.0	24.0	11.0	20.0	0.0	0.0
ICU	10	10.0	25.0	11.0	20.0	0.0	0.0
ICU Step-Down Unit	7	10.0	24.0	11.0	20.0	0.0	0.0
ICU Coronary Care Unit	7	10.0	24.0	11.0	20.0	0.0	0.0
ICU	21	10.0	20.0	11.0	20.0	0.0	0.0

Conclusions: Capnography care has expanded to multiple care environments across the hospital. Alarm limit requirements vary significantly from one environment to the next based on patient needs. Clinical units in these care environments may be less familiar with capnography monitoring alarms in alarm limits (non-experimental) than their own needs. Developing their own alarm limit settings. Each institution and attending physician should recognize that alarm limits should be adjusted based on the population being served and specific clinical needs.

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Setting Alarm Limits Abstract*

Patient and Family Education Key to Capnography Monitoring Compliance

Multiple organizations recommend capnography for monitoring patients who may be at risk of inadequate ventilation because of the depressive effects of sedatives and pain medications on respiratory drive. Patients receiving propofol sedation to control pain and those undergoing moderate to deep procedural sedation are good candidates for monitoring with capnography. Analysis of the American Society of Anesthesiologists Clinical Closed-Drainage in the course of elective general anesthesia revealed that more than half of cases of death and serious injury could have been prevented by better monitoring, including with capnography.

Patient compliance is an issue with any method of monitoring. When a patient wears a monitoring device, he or she is at risk of not monitoring correctly. Compliance involves an alarm that may be ignored, and eventually too many alarms can result in alarm fatigue.

The capnography monitoring the patient wears is small, and a nasal cannula interface. Through the interface, rebreathed CO2 is sampled and collected and inspired. The monitor displays supplemental oxygen. One advantage of capnography over other monitoring methods is that it doesn't require a second or third person to monitor the patient. Because many patients are already wearing oxygen to treat or prevent hypoxemia.

Two other patients worth properly informed about when they are being monitored. If patients are not educated about why the monitor is being used and do not understand the health it provides, there is a greater chance that he or she will remove the interface. If patients of capnography report they are not being monitored, the patient and family prior to the procedure and monitoring it during monitoring patients are more likely to be compliant.

"Patient education is the key. A well-educated patient and family is a key to having successful compliance with using capnography." Once the patient and the family understand that it is being done for safety for the safety, they're much more compliant. They don't have any issues regarding the monitor."

—Harold Ogilby, RRT, Director of Respiratory Care, St. Joseph / Chandler Hospital

"We've experienced really high compliance with our patients who have been using the end-tidal CO2 monitoring. It's very rare that once we've explained how important it is, that a patient says 'I don't want that on me now. Most patients do very well with it.'"

—Brian Robinson, MA, RRT, Director of Intensive and Medical-Surgical Administration, Valley Medical Center, Phoenix, AZ

"Patient education is the key to patient compliance. It would be ideal to educate patients prior to surgery."

—Christine Cox, RRT, Director of Respiratory Care, Wesley Medical Center, Wichita, Kansas

"Never mind and attitudes need to monitor capnography in spontaneously breathing patients are very well educated by adults."

—Madeline Layman, MD, Associate Professor of Pediatrics, Yale School of Medicine, New Haven, Conn.

"Our internal studies substantiate our finding that continuous monitoring by capnography is feasible in very young children."


—Madeline C. Layman, MD, MPH, Children's Hospital Boston, Boston, Mass.

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PATIENT EDUCATION
Breath Monitoring

Patient Compliance White Paper



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PATIENT EDUCATION
Breath Monitoring

Patient Education Brochure



It's important to educate your patients and their families about capnography.

Capnography can aid in patient recovery. It provides a fast, excellent method for clinicians to monitor breathing following procedures.

What can I tell my patients about capnography?
Explain that the medication they will be given can make their breathing slow or shallow. Explain that a capnography monitor will alert clinicians to small changes in breathing before any problems are present. Explain that patients may be sedated, it is also important to educate family or friends who are present.

What should I say about monitor alarms?
Let your patients and their family members know that alarms alert clinicians to a change in breathing. Explain that alarms can serve as a reminder for the patient to take a deep breath because they are awake.

Can patients drink liquids or eat while being monitored?
Breathing through a nasal cannula while eating or drinking does not interfere with monitoring.

How long are patients monitored?
Currently, patients will be monitored until the physician believes there is no longer a risk of slow or shallow breathing. This period depends on the type and duration of each case provided, as well as the patient's response to the medication.

Capnography provides:

- A means of ensuring oxygenation
- CO2 in every minute breath (end-tidal CO2)
- Respiratory rate
- Capnography monitor
- More

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Nurse Station Poster on Patient Education

* This abstract was written by Oridion employees and published at the Society for Technology in Anesthesia, 2011. Oridion was acquired by Covidien in 2012.

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- Explain that generally, patients will be monitored until the physician believes there is no longer a risk of slow or shallow breathing. This period depends on the type and duration of medication prescribed, as well as the patient's response to the medication.

Step 3 - Staff Education

A clear knowledge of the operation, alarm features, and limitations of monitors is a key to assessing and understanding causes of alarms, and taking steps to reducing alarms. The AACN Practice Alert on Alarm Management lists providing “initial and ongoing education on devices with alarms” among their recommendations.^{xiv}

Education increases the understanding of monitoring systems and how their alarms functions and should be managed. The American College of Clinical Engineering (ACCE) points out that, “Such learning must reach the level of operational effectiveness rather than just intellectual knowledge.”^{xx} In a quality improvement project, retraining nurses was the first step in a multipronged approach to reduce the number of false alarms.ⁱ This project demonstrated that after receiving education and retraining, nurses individualised alarm settings at the outset, instead of adjusting settings in response to continual activation of an alarm.

Such training should include discussion of proper sensor selection, application, and replacement.^{xiv}

Clinicians should be aware of monitor limitations that reduce effectiveness based on patient characteristics (e.g., use of oximetry with certain pigmentations or drugs).

As mentioned previously, a retrospective analysis of alarm data has been key to several efforts that have shown positive results.^{xi,xii} A clear understanding of how to review alarm data, trends, waveforms, and other available data can be invaluable in identifying causes of

alarms. In many cases, a review of such data may reveal that multiple alarms thought to be ‘false’ are indeed real when explored in more detail.

Papers from Maddox describe several case studies where retrospective review of monitor alarm data and trends was useful in identifying underlying causes of alarms that resulted in changes to management correcting the underlying problem.^{x,xxi}

One such example cited by Maddox is patients with underlying sleep apnoea. Sleep apnoea is common in hospitalised patients and the vast majority may be undiagnosed.^{xxii} Commonly used sedatives and analgesics may exacerbate the condition. Patients with sleep apnoea may trigger repetitive apnoea, low RR, or high ETCO₂ alarms and the sound of the alarm or the nurse entering the room may wake the patient resulting in ‘self-correction’ from the alarm. This can lead to the perception that the alarm was ‘false’. Reviewing trend data was helpful in identifying such conditions, leading to appropriate management and elimination of many alarms.

Along with implementation training, education should continue at the bedside. Several programs have identified the benefit of utilising Respiratory Therapists’ expertise in respiratory monitoring to help educate other clinicians who may be less familiar with its benefits and limitations.^{xxiii,xxiv}

Covidien Support

On-site, web-based, and written educational materials are available from Covidien to assist in clinician training. In addition, Covidien has developed multiple technologies to assist with alarm management. More information can be found in the ‘Supplemental Covidien Materials’ section at the end of this document and is available from your Covidien representative. Covidien is committed to working in partnership with customers, thought leaders, and clinical societies to develop additional technologies, education, and strategies for more effective alarm management.