Focus Spring Conference
Orlando, FL

Alarm Management & Safety

ECRI Institute

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Speaker Information

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– Senior Associate/Consultant, ECRI Institute
– 37 years experience as a RT
– 34 years management experience
– 15 years Senior Director of Ancillary Services, Aria Health
ECRI Institute

Founded in 1968
• “Consumer Reports” of healthcare

• Max Cart
  • https://www.youtube.com/watch?v=92Vpc5mFMjA
One ECRI . . . Many Solutions

Customized Consulting
Agenda

- The Joint Commission National Safety Patient Goals (NPSG) 06.01.01
  - What is it?
  - How does it effect you and your department?

- Alarm Fatigue and Patient Safety

- Alarm Management

- Middleware
Legal Disclaimer

Throughout this presentation, there may be images of specific manufacturer technologies. These images are used only as an example of the technology being discussed and in no way are a endorsement by either ECRI Institute or the speaker.
The Joint Commission's National Patient Safety Goal (NPSG) .06.01.01
Specific Recommendations for Joint Commission Compliance

- Start a hospital wide alarm committee with multidisciplinary representation.
- Alarm safety must be established as a priority on all levels with Senior Leadership sponsorship and top-down engagement.
- Develop clear policies regarding alarm management including response to alarms, customizing alarm limits, etc.
- Every RN, RT, PCT, MD, etc. should be able to speak to at least one thing their unit is doing to improve alarm fatigue.
NPSG .06.01.01

Does your hospital / department meet the goals?

- Training?
- Audits of all medical devices that alarm?
- Review of past events involving alarms?
- Near misses?
- Customize ventilator alarm parameters to meet individual patient needs?
- Do policies specify who may adjust alarms?
The Good, The Bad, and The Ugly of Medical Alarms
TJC comes out with a two phase approach to combat alarm fatigue after some high profile cases leading to adverse events
- Phase 1 – July 2014 – establish Alarm Fatigue as a priority
- Phase 2 – January 2016 – Have policies and education in place to combat alarm fatigue
- Some hospitals have recognized this as a priority and have done a good job in creating an appropriate alarm management strategy
Many hospitals have not formally started on TJC Phase 1 standards. Some have recognized that alarm fatigue is real and they may have had some incidents related to alarm fatigue.
• Despite The Joint Commission’s emphasis on alarm safety and improving alarm fatigue, multiple incidents surrounding medical alarms continue to occur that lead to patient harm, including death.
ALARM FATIGUE
and
PATIENT SAFETY
“Unnecessary noise is the most cruel abuse of care which can be inflicted on either the sick or the well.”

~ Florence Nightingale
Alarms – What Patients Say

■ 77% responded that alarms DISTURBED their sleep
■ 60% noted that alarms were CONSTANLY BEEPING
■ 58% responded that the alarms made them ANXIOUS
■ 51% thought the alarms went off for NO REASON
■ 42% believe that alarms have a NEGATIVE impact on their healing
■ 37% said it made them more aware of their PAIN

■ 35% thought the hospital did a good job of explaining the alarms
■ 34% felt the staff responded to alarms in a timely manner
■ 27% felt the hospital managed the overall noise effectively
■ 23% felt the hospital proved a quiet healing environment

2014 WEGO survey of hospitalized patients
Ventilator Alarms
Past and Present
Ventilator Alarms
Non-Connected
Ventilator Alarms
Connected via Nurse Call
Ventilator Alarms
Connected via Central Station
Ventilator Alarms
Fully Integrated
How big a deal is this?

- Up to **350 alarms** per day per ICU patient!
- **Ranked #1** on ECRI’s 2014 & 2015 Top 10 Technology Hazards List
- 2014 Joint Commission **National Patient Safety Goal on Alarms**

> “The Joint Commission received 98 reports of alarm-related incidents — including **80 deaths** — in the 3½ year period ending in June 2012.” *

*Too much noise from hospital alarms poses risk for patients, Washington Post, July 7, 2013*
Culture Conundrum of Alarms

I'm too busy to deal with this!

This is the way we've always done things.

If the nurses would just do their job, we wouldn't have a problem.

It's not my job!

We don't have any problems. We've never had an alarm event.

What's the use? Nothing is ever going to change.

Why should I rush to put the leads back on? They're just going to come off again.

It's the vendor's fault!
Underlying Causes of Alarm Fatigue

- Units have high noise level and too many alarms
  - Monitors, infusion pumps, ventilators, call bells, phones, etc.
- False alarms vs nuisance alarms
- Decrease/elimination of non-actionable alarm
- Alarm limits are not tailored for individual patient
- All alarms to clinicians
- Redundancy of alarms (low Vt and Ve)
Reducing the Frequency of Nuisance Alarms

- Make alarms actionable
  - Analyze unit default settings
  - Tailor alarms per patient
- Alarm escalation plan
- Reinforce the high-urgency to address alarms
The Perfect Alarm

100% Specificity

100% Sensitivity
The Stories

- Large 85+ hospital national network
  - Recognized the issue and acted upon it urgently
  - All team members were engaged
  - Urgency was evident
  - Successful implementation plan
  - ZERO incidents involving patient monitoring or ventilators in 3 years
13 Hospital System

- Alarm policies across the system went from non-existent to robust
- Practices varied unit by unit, hospital by hospital
- Several sentinel events related to alarm fatigue
- Standardized polices and practices
- Standardized middleware solutions and business rules
The Stories

- Large Academic Teaching Hospital

- Christmas day patient death due to monitor speakers being unplugged.

- On another day, in another unit, the speakers were covered with towels.

- Nursing staff, including managers oblivious to alarms sounding for over 20 minutes during our visit.
The Stories

5-hospital system

- Invested over $300k in an elaborate ventilator monitoring system
- Patient became disconnected from a vent while in the ED for 16 minutes
- 7 RN’s 2 MD’s, plus residents in immediate area. No one responded.
- The ventilator monitoring system worked and sent multiple pages, but the pagers were off, in the department, some without batteries.
- The patient died.
The Stories

▶ Community Hospital

- Utilized “war room” concept for telemetry monitoring
- Newer equipment
- “Leads off” alarm was considered “low priority” with an escalation scheme totaling over 20 minutes.
- Alert for a patient with a leads off alarm went to PCA, escalated to RN, escalated to charge nurse and finally nursing supervisor via VOLTE system.
- Patient was found pulseless. Resuscitation attempts were not successful.
The Stories

- Pediatric LTC Facility
  - Installed elaborate oximetry monitoring system
  - Ventilators not remotely monitored and difficult to hear outside of room.
  - 1 RN/4 patient room. 1 RT/4 rooms (quad)
  - RN left room for bathroom break and didn’t inform covering nurse
  - Patient became disconnected from ventilator.
  - Pulse oximetry alarm did alarm, but patient sustained additional brain damage from being disconnected from ventilator.
ALARM MANAGEMENT
Alarm Management

Alarm management is the application of human factors (or 'ergonomics') along with instrumentation engineering and systems to manage the design of an alarm system to increase its usability and effectiveness.

Alarm Management = Reduce non-actionable alarms and increase recognition of actionable alarms
STRATEGIES TO IMPROVE MONITOR ALARM SAFETY

Alarm Management is Complex

- Staffing Patterns
- Care Model
- Patient Population
- Delineation of Responsibility
- Culture
- Ancillary Technology
- Alarm Coverage Model
- Architectural Layout
- Technology Capabilities & Configuration

Minimize patient safety vulnerabilities and reduce risk

Improve the effectiveness and efficiency of alarm management

ECRI Institute
The Discipline of Science. The Integrity of Independence.

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Alarm Management

Lots of Hurdles!

• Data is not easy to come by
• Minimal literature and evidence based research on alarms
• One sized solutions do not fit every unit, situation or hospital
• Culture is hard to change
Alarm Management

Medical device alarm safety

Scope of problem

100s → 1,000s → 10,000s

100s of alarm signals per patient, per day = 1,000s
of alarm signals on each unit = tens of thousands
of alarm signals throughout a hospital per day

85-99% of alarms don’t require clinical intervention

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# Alarm Management

<table>
<thead>
<tr>
<th>Weekly Report</th>
<th>CVSICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave Beds Reporting Alarms/ Day</td>
<td>14</td>
</tr>
<tr>
<td>High Priority</td>
<td>186 (1%)</td>
</tr>
<tr>
<td>Medium Priority</td>
<td>1972 (9%)</td>
</tr>
<tr>
<td>Low Priority</td>
<td>16080 (77%)</td>
</tr>
<tr>
<td>Technical</td>
<td>2603 (12%)</td>
</tr>
<tr>
<td>TOTAL ALARMS</td>
<td>20841</td>
</tr>
<tr>
<td>Ave Alarms/Beds/Day</td>
<td>208</td>
</tr>
</tbody>
</table>
Alarm Management

Ventilators = 2nd leading cause of alarm related death by device
Alarm Management

Medical ICU
Surgical ICU
Neurosciences ICU

10 week period
Avg. # of alarms/ventilator
Avg. alarm duration
# Alarm Management

<table>
<thead>
<tr>
<th>Total # MV Alarms/10 Weeks</th>
<th>Frequency of Alarms/Vent/Day</th>
<th>Alarm Duration</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>27,607</td>
<td>16.15</td>
<td>15.85</td>
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</table>

Staff Surveyed If They Would Respond To an Alarm Lasting 5 Seconds or Less

<table>
<thead>
<tr>
<th>N = 539</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Likely</td>
<td>Somewhat Likely</td>
</tr>
<tr>
<td>50%</td>
<td>30%</td>
</tr>
</tbody>
</table>
Alarm Management

- % < 5 seconds: 35.97%
- % ≥ 5 seconds: 64.03%

5 sec delay

17,677 alarms eliminated

Avg. # of alarms per vent per day = 16.15

Avg. # of alarms per vent per day = 5.81
MIDDLEWARE
Middleware

Middleware is a term most commonly used for software that enables communications and the management of data in a distributed application.
Middleware

Critical Functions of Middleware

- Prioritization of alarms
- Staff assignments
- Alarm escalations
- Routing assignments
  - Individual
  - Group
- Report generation and information logs
- Complex event processing
Alerting Middleware May Be Part of a Larger Secondary Alerting Application

- Patient Monitors /Tele
- Smart Beds
- Fetal Monitors
- IV Pumps
- Other

**Messaging Middleware**
- Associations: Patient, Nurse, Phone
- Prioritization
- Routing
- Escalation
- Complex Event Processing

**Nurse Call**
- Early Warning System
- Lab System
- Environmental
- Interactive Patient Education
- Other
- EMR

**Staff Assignments**
- Time&Attendance/Scheduling/Absence Mgmt

**Telecom System Call Manager**
- PCD Manager
  - Message Org
  - Color Code

**Personal Communication Device (PCD)**

**Public Telephone Network**
Middleware Reports

Provided as a courtesy by Cardiopulmonary Corporation
# Middleware Reports

## Flowsheet Report for Patient: Fert. Robern - 99494949

**Date:** 9/23/2016 4:42:05 PM to 9/26/2016 4:42:05 PM  
**Options:** Scheduled, Manual, Settings Change, Alarm, Notes  
**Generation Time:** 9/26/2016 4:42:46 PM

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Event Type</td>
<td>Scheduled</td>
<td>Settings Change</td>
<td>Settings Change</td>
<td>Settings Change</td>
<td>Alarm</td>
</tr>
<tr>
<td>Event</td>
<td>Scheduled Snapshot</td>
<td>Ti % set to 5</td>
<td>Ti Rise % set to 1</td>
<td>Pressure set to 1</td>
<td>High Saturation at 99</td>
</tr>
<tr>
<td>Device ID</td>
<td>CB223</td>
<td>CB223</td>
<td>CB223</td>
<td>CB223</td>
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<tr>
<td>Snapshot ID</td>
<td>1325256</td>
<td>1340171</td>
<td>1340172</td>
<td>1340173</td>
<td>1340189</td>
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**Settings**

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>ADULT</th>
<th>ADULT</th>
<th>ADULT</th>
<th>ADULT</th>
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<tbody>
<tr>
<td>SatSeconds</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</table>

**Measurements**

<table>
<thead>
<tr>
<th>SpO2</th>
<th>99</th>
<th>99</th>
<th>99</th>
<th>99</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse</td>
<td>80</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>54</td>
</tr>
</tbody>
</table>

**Alarm Limits**

<table>
<thead>
<tr>
<th>High SpO2 Limit</th>
<th>100</th>
<th>100</th>
<th>100</th>
<th>100</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low SpO2 Limit</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>High Pulse</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
</tr>
<tr>
<td>Low Pulse</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

**Alarms**

<table>
<thead>
<tr>
<th>Initials</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

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Alarm Integration
Middleware System Design

• Alarm Integration systems are complex
  – Require a multidisciplinary approach
  – Unique to each organization
  – Should fit into the alarm management model of the hospital
Alarm Integration System Design

- **Alarm Source**
  - Physiologic Monitors
  - Ventilators
  - Nurse Call
  - Infusion Pumps

- **Middleware**
  - Systems that collect the alarm information from the primary alarming devices
  - Prioritization of incoming alarms/alerts
  - Customizable by the hospital to fit their needs
  - Reporting abilities
  - Nursing assignments
  - Escalation schemes
Alarm Integration System Design

- The building blocks

Alarm Source → Middleware → Communication Engine → End Devices
Design Team

- Get the right team together

- A good team will incorporate both internal and external team members
  - Internal - Facilities, Clinical Engineering (CE), Nursing, Clinical staff, IT
  - External – Staff from middleware, medical device vendor, communication systems vendor
Consider a road map for your implementation

**Foundation Phase**
- Establish Implementation team and support structures
- Customize Middleware and business rules
- Analyze your wireless infrastructure
- Pilot
- Establish a test site

**Maturation**
- Scale the Middleware and introduce multiple units
- Create specific business rules / unit
- Continue analysis of wireless infrastructure
- Establish failsafe methodologies to mitigate large scale failure
End User Alerting Devices
Thinking of Implementing?

Issues to Consider

- Architectural layout
- Nurse to Patient ratio
- Technology limitations
- Testing, testing and testing

Possible Vendors

- Amcom
- Amplion
- Ascom
- Cardiopulmonary Corp
- Cerner
- Connexall
- Extension
- Philips/Emergin
- Vocera
Homer’s Approach to Alarm Management

“This is my ‘everything is okay alarm.’ It will sound every 3 seconds unless something isn’t okay.”
Thank you...
Questions?

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