

Current Challenges with Ventilator Alarms

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Speaker Introductions

- **Thomas Krüger**, Senior Product Manager, Respiratory Care, Dräger Medical GmbH
- **Russelle A. Cazares, MHA, RRT**, PCS Manager, Respiratory Care Services, Children's Hospital Los Angeles
- **Matthew P. Trojanowski, MSc, RRT**, Manager, Adult Respiratory Care Services, Anesthesiology & Critical Care Medicine, The Johns Hopkins Hospital
- **Shawna Strickland, PhD, RRT-NPS, AE-C, FAARC**, Associate Executive Director, Education, American Association for Respiratory Care (Moderator)

Introduction

Shawna Strickland, PhD, RRT-NPS, AE-C, FAARC
Associate Executive Director, Education
American Association for Respiratory Care

Webinar Goals

- Problems with ventilator alarms
- Vendor perspective of alarm standards
- Best practices in alarm safety and quality improvement
- Limitations and barriers to alarm safety
- Recommendations on managing bedside alarms

Identifying the Problem

- Clinical alarm systems
 - Purpose: alert caregivers to changes in patient status
 - Problem: missed or ignored alarms
 - Alarm settings too broad or too narrow
 - Overwhelming number of alarms in patient care area
 - Result: potential patient care compromise

Necessity of the Topic

- Ventilator alarms
 - Unique sounds/settings
 - Parameter settings
- 2008 HTF survey
 - Nuisance alarms occur too frequently
 - Nuisance alarms reduce trust in alarm systems
 - Difficulty in hearing alarms
 - Confusion in determining cause of alarm

http://thehtf.org/documents/2011_HTFAlarmsSurveyOverallResults.pdf

TJC National Patient Safety Goal on Alarm Management (NPSG.06.01.01)

- Effective January 1, 2014
- Purpose: improve the safety of clinical alarm systems
 - Focus on managing clinical alarm systems that have the most direct relationship to patient safety
- By January 1, 2016:
 - Establish policies and procedures for managing alarms
 - Educate staff about purpose and proper operation of alarm systems

http://www.jointcommission.org/assets/1/18/JCP0713_Announce_New_NSPG.pdf



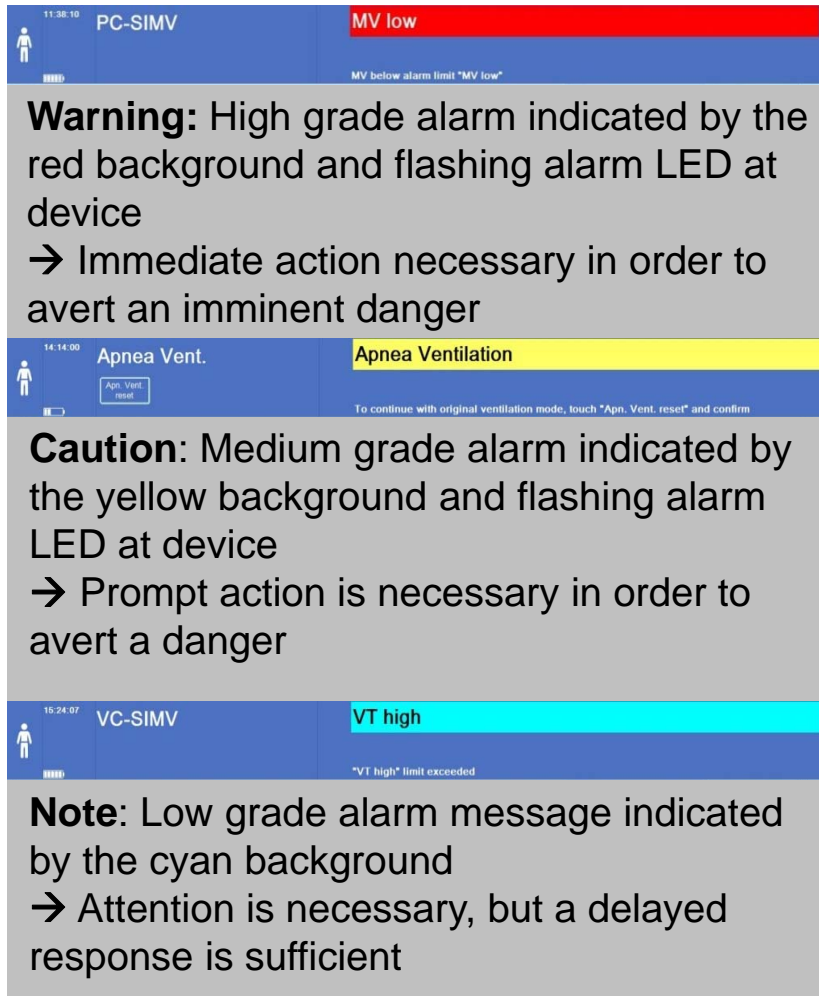
Industry Perspective on Ventilator Alarms

Example: Implemented Alarm Behaviour Dräger Evita Infinity® V500

Thomas Krüger, Dräger Medical

General Information and Alarm Grades

Alarm grades



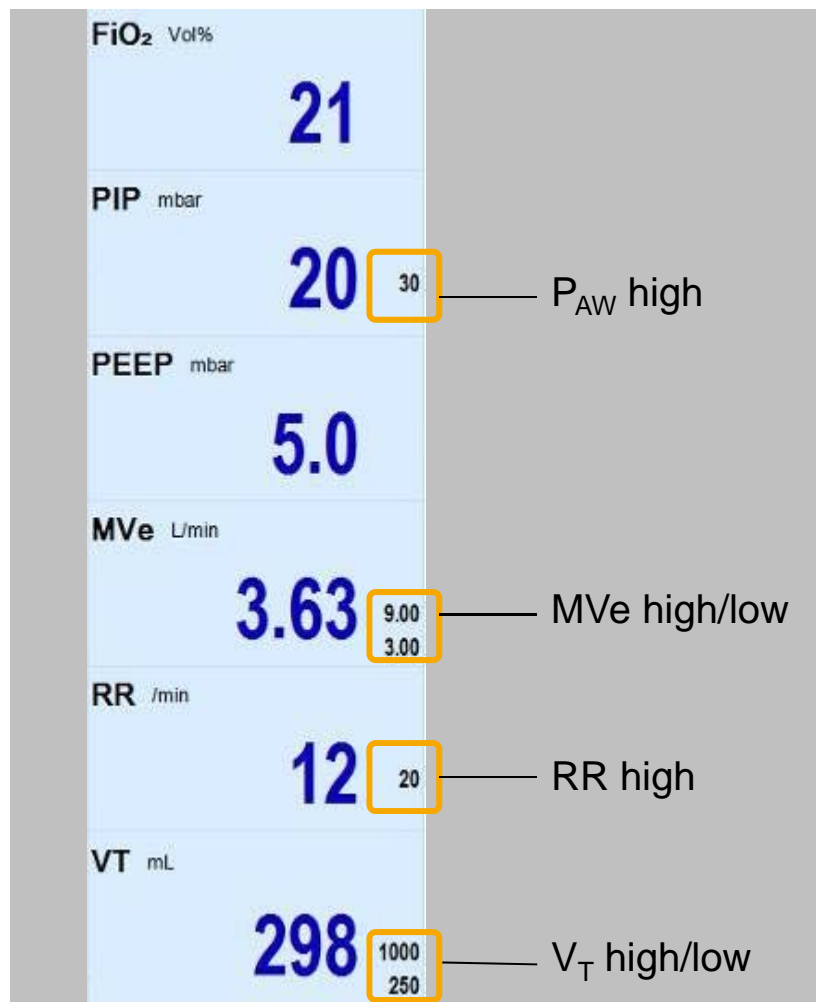
Warning: High grade alarm indicated by the red background and flashing alarm LED at device
→ Immediate action necessary in order to avert an imminent danger

Caution: Medium grade alarm indicated by the yellow background and flashing alarm LED at device
→ Prompt action is necessary in order to avert a danger

Note: Low grade alarm message indicated by the cyan background
→ Attention is necessary, but a delayed response is sufficient

- **Alarming is based on:**
 - Risk assessment
 - IEC 60601-1-8
- **Signals used for alarming:**
 - Flow
 - Pressure
 - Gases (FiO₂ and etCO₂)
- **Auditory alarm signals**
 - IEC tones
 - Draeger ventilator alarm tones
- **Alarm silence**
 - Alarm can be silenced for a maximum of 2 minutes
 - Silence state is indicated on screen
- **Monitoring source deactivation**
 - Not monitored parameters will also not be alarmed
 - Deactivation is indicated on screen

Alarm Limits



- **Adjustable alarm limits**

- Limits for some alarms can be set by the user, e.g. MVe high/low (see below)
- Set alarm limits are displayed in the respective parameter boxes on screen (see picture left)

- **Non-adjustable alarm limits**

- Multiple different alarms have fixed thresholds or thresholds that are linked to settings (no user adjustment needed)

Alarms [X]

Limits	Current alarms	Alarm history	Settings				
	MVe L/min	MV delay s	Paw mbar	RR /min	Tapn s	VT mL	etCO ₂ mmHg
√	9.00	0	30	30	15	1000	
Current value	5.47		18	12		501	Off
√	3.50	0					

Alarm Priorities, Latching, & Escalation

Alarm priority	Alarm message	Cause	Remedy
!!! 200	Airway pressure low	Leakage or disconnection.	Check breathing circuit for tight connections. Check whether the expiratory valve is properly engaged. Make sure that the tube or mask is connected correctly.
!!! 140	Airway pressure negative	Airway pressure has fallen below -10 mbar (-10 cmH ₂ O). The breathing hose is connected to the expiratory valve during O ₂ therapy.	Disconnect tube for suctioning. Check patient condition. Check ventilation settings. Connect breathing hose to the inspiratory valve.
! 120	Alarm system failure	Failure of primary alarm speaker. In case of an alarm situation, the auxiliary acoustical alarm will sound.	To continue ventilation with this device, continuously monitor the device functions. Call DrägerService.
!! 100	Ambient pressure sensor?	Altitude setting deviates too much from measured ambient pressure. Ambient pressure sensor failure.	Check altitude setting and adjust if necessary. If the setting has been adjusted, the device check must be repeated. Accuracy of measured values depending on the atmospheric pressure could be impaired (e.g., MV, O ₂ concentration). Call DrägerService.
!!! 181	Apnea	The patient has stopped breathing. Obstruction. Flow sensor is not calibrated or faulty.	Check patient condition. Apply controlled ventilation if necessary. Check patient condition. Check breathing circuit. Check tube or mask. Calibrate flow sensor and replace it if necessary.

- **Alarm priorities**

- Alarms are prioritized by grade (red, yellow, cyan) and by given priority within one grade in order to allow most important alarm being displayed first
- Configuration of priorities by user not possible (fixed)

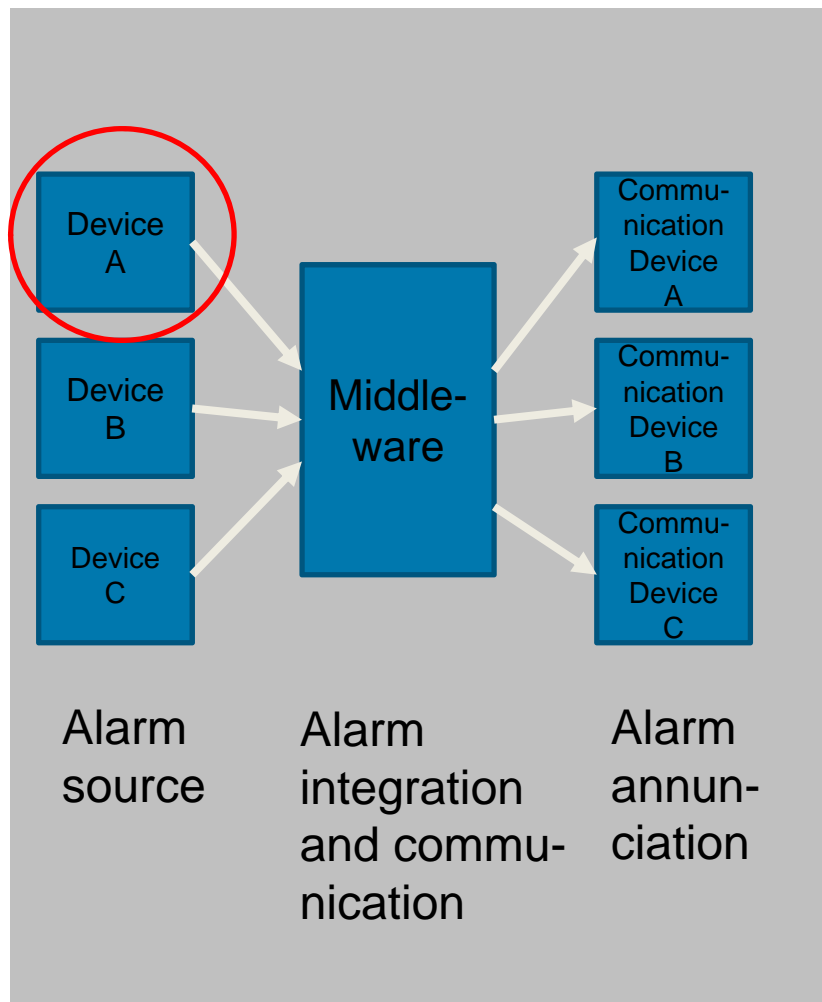
- **Alarm latching**

- Used for high grade alarms only
- Configuration by user not possible (fixed)

- **Alarm escalation**

- Automatic alarm escalation is not used by the ventilator

Reduction of Nuisance Alarms



- Dräger wants to reduce nuisance alarms at the origin
- Changes of alarms are based on field data and customer feedback
- Dräger analyzes alarm logbooks in order to detect the frequency of occurrence of specific alarms
- Project specific alarm logs are systematically analyzed for potential alarm reduction measures using patient clinical context data
- Based on such analysis, Dräger continuously improves alarm criteria and algorithms in order to reduce nuisance alarms

Summary



- Implemented alarms based on normative, regulatory and risk management requirements
- Alarm grades and priorities are based on the potential risk and speed of needed action
- “Alarm fatigue” is recognized and is field for research and development
- Further changes need to balance patient safety, user comfort and user attention and has to comply with international standards

Ventilator Alarms and Secondary Systems

Russelle A. Cazares, MHA, RRT
Manager, Respiratory Care Services
Children's Hospital Los Angeles

Objectives

- To increase knowledge and understanding of the different barriers related to ventilator alarms integration with secondary systems
- To understand industry challenges of ventilator alarm management
- To understand different strategies for managing ventilator alarms at the bedside

Ventilator Barriers

- Inconsistent and complicated alarm packages with different ventilators
 - Issues related to integration with secondary systems
 - Variation in available alarm settings
 - Inconsistent nomenclature

Ventilator Barriers (cont'd)

- Limited autonomy allowed at bedside
 - Inability to customize alarm algorithms and delays
- Inconsistent ability to transmit alarm data to 3rd party (EMR, secondary alarm notification)
 - Serial port, IP port
 - Special packages required
 - Limited data elements available

Industry Challenges

- TJC NPSG to improve ventilator alarm management
- Lack of research to determine best practice for alarm settings
- Need for greater understanding regarding alarms and alarm fatigue problem for respiratory therapists and nurses
- Need for broader understanding about alarm methodology deployed by vendors for respiratory therapists and nurses
- Need for more options for secondary alarm notification

Current State of Industry Secondary Notification

Requirement:

The ventilator itself has the ability to transmit alarm data. Many of the 'specialty' ventilators will not have this option or if they do, the data elements available are limited.

Today there are 3 technical options on the market to allow ventilator alarms be sent to a caregiver's mobile device as a secondary alarm notification.

Option 1: Ventilator to Auxiliary Jack - Nurse Call

- Advantages
 - Allow middleware to implement a delay of 'x' seconds prior to dispatching to mobile device
 - Allows for designated care givers to be notified
 - Allows for audible and visual alarm outside the patient room and in the central phone console
- Limitations
 - May require middleware software
 - Dedicated auxiliary port required
 - Alarm is generic – will only send a message as a “vent alarm”
 - Every vent alarm will be dispatched
 - Patient with a large airway leak may trigger constant low pressure alarm that may result in nuisance alarm

Option 2: Ventilator Alarm Pack to Patient Monitor

- Advantages
 - Allow middleware to implement a delay of 'x' seconds prior dispatching to mobile device
 - Allows for designated care givers to be notified (e.g., nurse and respiratory therapist)
 - Allows user customization of visual and audible alarm type at patient monitor
 - Allows for audible and visual alarm at central monitor station
 - Allows patient data to be transferred to the EMR
- Limitations
 - Requires middleware software
 - Number of data elements is limited
 - Only certain ventilators have the ability to interface with the patient monitor

Option 3: Ventilator to Integrators and Middleware

- Advantages
 - Allow middleware to implement a delay of 'x' seconds prior to dispatching to mobile device
 - Allows for designated caregivers to be notified
 - Allows HCOs to choose at a granular level which alarm and at what priority they are to be dispatched (e.g., low press = high priority; high respiratory rate may not be sent at all)
- Limitations
 - HCOs must purchase 2 software solutions to achieve desired outcome
 - HCOs must deal with multiple vendors that do not always communicate

Management of Primary Ventilator Alarms

- Evaluate and study your organization's current ventilator management
 - Understand respiratory therapists' practice on ventilator alarm settings
 - Prerequisite prior to implementation or changes with your secondary notification system
 - Multidisciplinary approach
- Respiratory therapists' responsibilities
 - Set alarm limits based on individual patient condition and assessment
 - Designated primary responder for all ventilator alarms
 - Determines the most important ventilator alarm and expected response
 - Shared sense of responsibility with nurses and other clinicians
 - Best practice in alarm management

Opportunities for Secondary Alarm System

- Ventilator manufactures should work to provide more options
 - Add delay for specific alarms
 - Standardized nomenclature for alarms and alarm events
 - Involve respiratory therapists and other clinicians to determine best practice guidelines driven by patient safety
- Integrators and middleware providers should develop cost-effective solutions for HCOs
 - Multiparameter and intelligent alarms
- HCOs should work with industry to obtain research funding and methodology to provide evidence-based best practice guidelines
 - Redirect our attention to alarm signals that's more important, and data driven
 - Share outcomes data

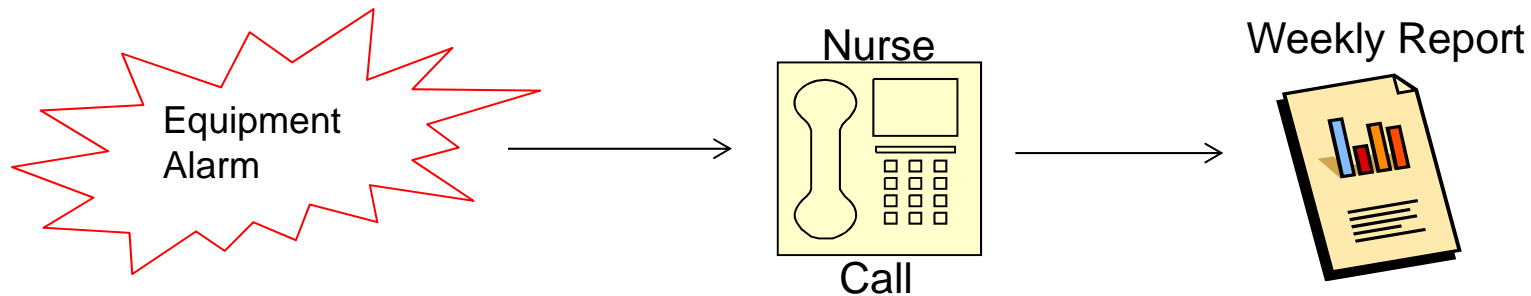
Look Before You Leap: Evaluating Current Practice for Ventilator Alarm Management

Matthew P. Trojanowski, MSc, RRT
Manager, Adult Respiratory Care Services
Anesthesiology & Critical Care Medicine
The Johns Hopkins Hospital

Objectives

- By examining a pilot program at The Johns Hopkins Hospital, participants will:
 - Understand the importance of characterizing the current situation and evaluating current practice at your institution to produce data-driven change for management of ventilator alarms
 - Understand why it is important to focus on the elements of performance for phase I of NPSG 06.01.01 before making changes to practice

Current Rate of Ventilator Alarms in Pilot Unit



- Average of 173 ventilator alarms/day/unit
- Duration (sample of 1213 ventilator alarms)
 - Mean: 4.32 sec
 - % > 10 sec: 7.09%
 - % > 20 sec: 1.65%
 - % > 30 sec: 0.49%

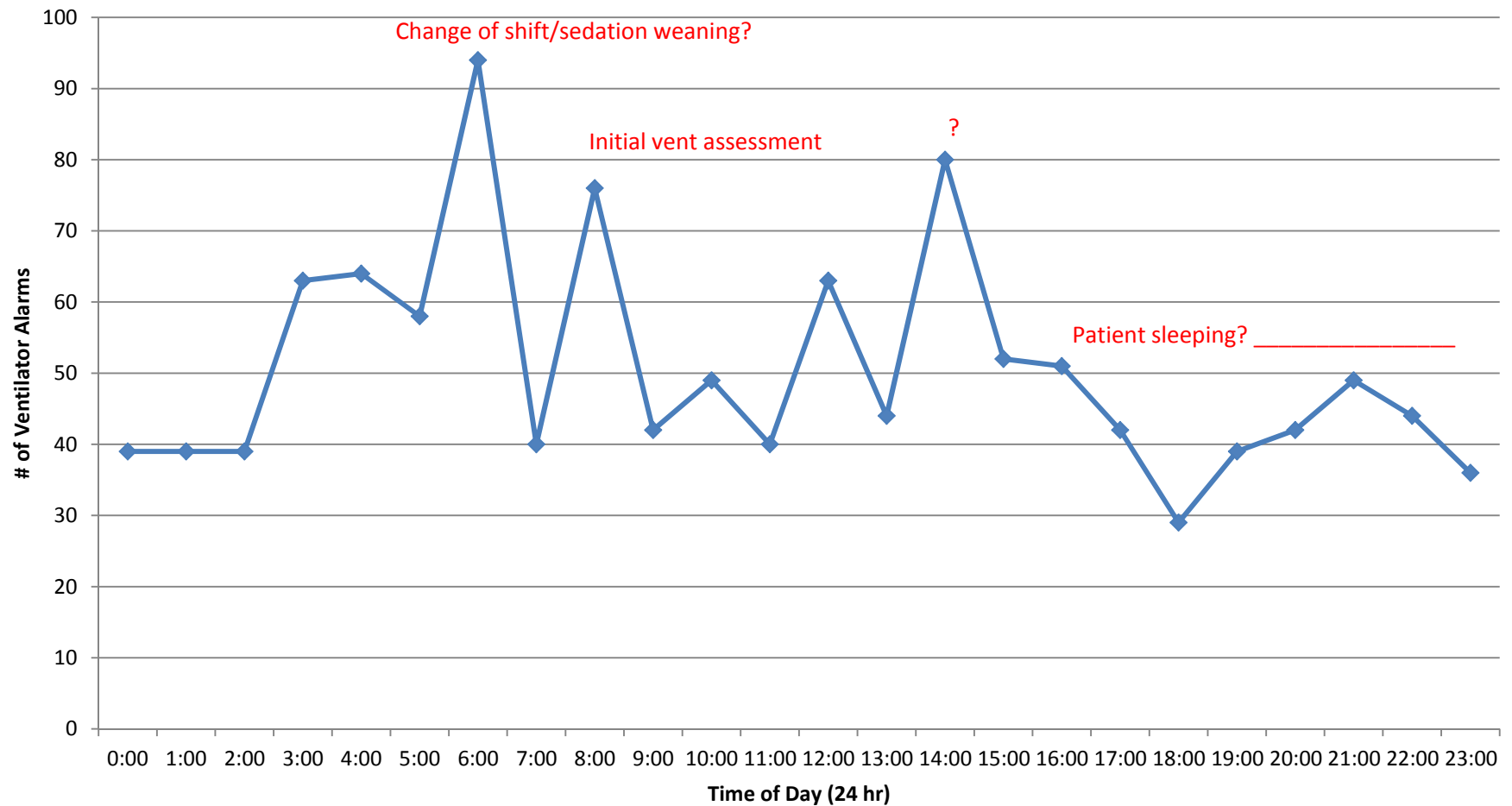
Nearly 91% of the 1,103 alarms were < 10 sec in total duration... are these actionable?

- Challenges of Data

- At this point, not distinguished as actionable vs. non-actionable
- Unable to determine specific alarm condition
- Unable to determine priority level of alarm

Number and Timing of Alarms

of Alarms per Week by Time of Day



Evaluating Current Practice in a Pilot Unit

- Respiratory therapy approaches to setting alarms in volume-controlled ventilator modes
 - No policy in place at this time
 - Settings based off clinician intuition
 - Respiratory therapists have complete control of ventilator alarm settings
 - Neurological Intensive Care Unit (NCCU)
 - One ventilator model
 - 30 patient charts randomly selected for review during a 6-month timeframe in 2013
 - Evaluated the following ventilator parameters through randomized, retrospective chart review
 - Minute volume, tidal volume, respiratory rate, inspiratory pressure
 - Averaged parameters over 24 hours
 - Alarm settings set by respiratory therapist

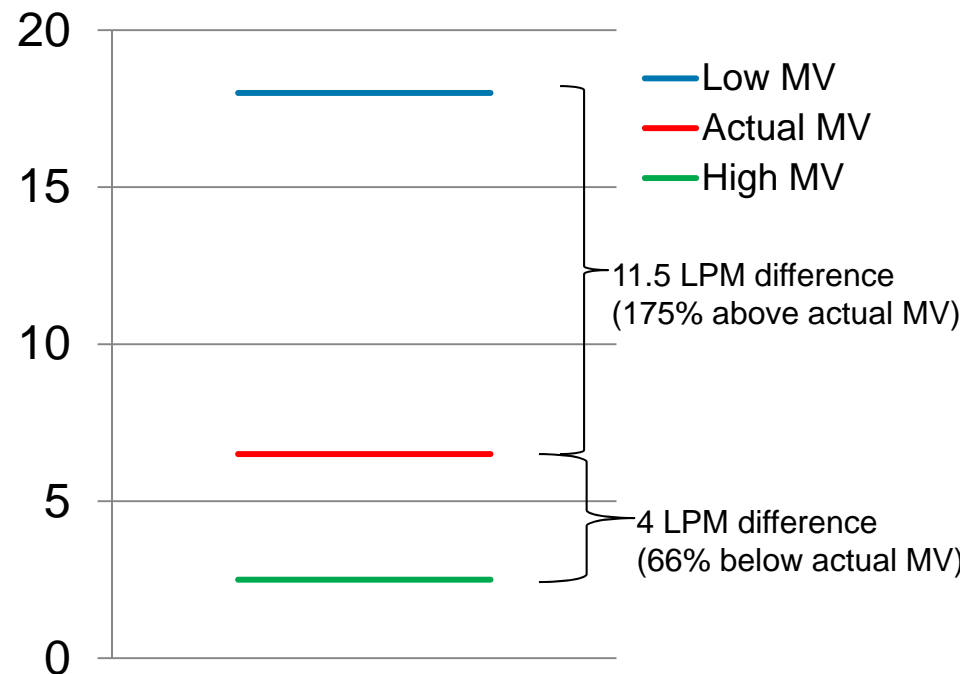
What We Found....

- Respiratory therapists set similar limits regardless of ventilator settings/patient characteristics
 - “One size fits all” approach apparent
- Significant variation in the % change of patient parameter required to trigger alarm
 - Similar/“default” alarm limits used for patients with different ventilator settings/measurements, and pulmonary characteristics
- In general, the lower limit was set more conservatively than the upper limit for all parameters
- Clinician intuition/conditioning
 - No evidence to confirm using “fixed” thresholds is “better/worse” than using % change

Example: High and Low Minute Volume Alarm

Alarm Parameter Setting
% Variation from Patient Actual Minute Volume

	High MV	Low MV
Mean	174.42%	61.03%
Min	55.04%	8.26%
25 th Percentile	92.06%	56.34%
Median	176.22%	66.04%
75 th Percentile	228.14%	71.59%
Max	358.72%	79.70%
Range	303.68%	71.44%



Where We Go From Here...

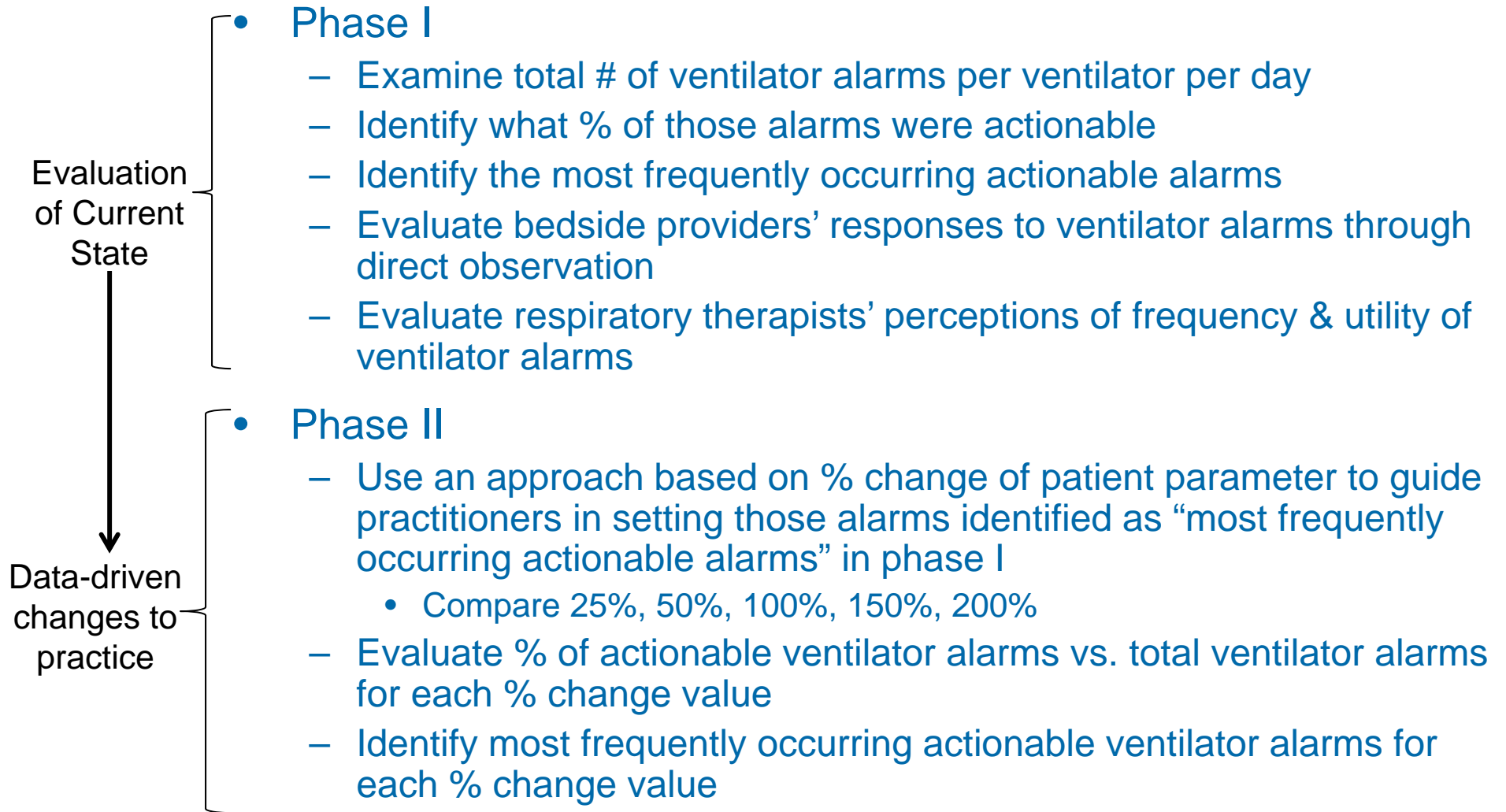


Phase I of NPSG.06.01.01

- ✓ Establish alarm management as an organizational priority
- Identify most important alarms to manage
 - Inventory of all potential ventilator alarm conditions
 - Pilot program to identify most important ventilator alarms to manage



Where We're Headed...



Don't start with creating/redoing a policy. The policy should be the end result of your intervention & analysis process

Compile and evaluate existing data to identify areas for improvement

Pilot different interventions to address what you discovered in your baseline analysis

Create guidelines/policy for ventilator alarm management

Summary

- TJC NPSG
 - January 2016 deadline
- Industry recognizes alarm fatigue
 - Research and development
- Identify appropriate ventilator notification
- Departmental/organizational guidelines

Closing Reminders

Thank you for your time and attention!

Mark Your Calendars!


Educating and Training Your Staff: Circling Back to
Your Policies and Procedures

Tuesday, April 29, 2014

1:00-2:00 pm Eastern

www.aami.org/htsi/events.html

LinkedIn - Questions

Join our group ™

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LinkedIn page:

<http://www.linkedin.com/groups/Healthcare-Technology-Safety-Institute-HTSI-4284508>

Continuing Nursing Education 1.0 contact hour

For those desiring CNE, please visit the link below
for the test, evaluation form, and certificate:

<http://www.aacn.org/DM/CETests/Overview.aspx?TestID=1090&mid=2864&ItemID=1082&menu=CETests>

The American Association of Critical-Care Nurses (AACN) is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

Continuing Respiratory Care Education 1.0 contact hour

For those desiring CRCE, please visit the link
below for the evaluation form:

<http://www.surveymonkey.com/s/W6JQNXX>

American Association for Respiratory Care

Evaluation Form and Certificate of Attendance (Non-CE and Non-CRCE)

Please let us know how we did!

<http://aami.confedge.com/ap/survey/s.cfm?s=Ventilators>

After you fill out the evaluation form and enter your email address, you will receive an electronic certificate by email