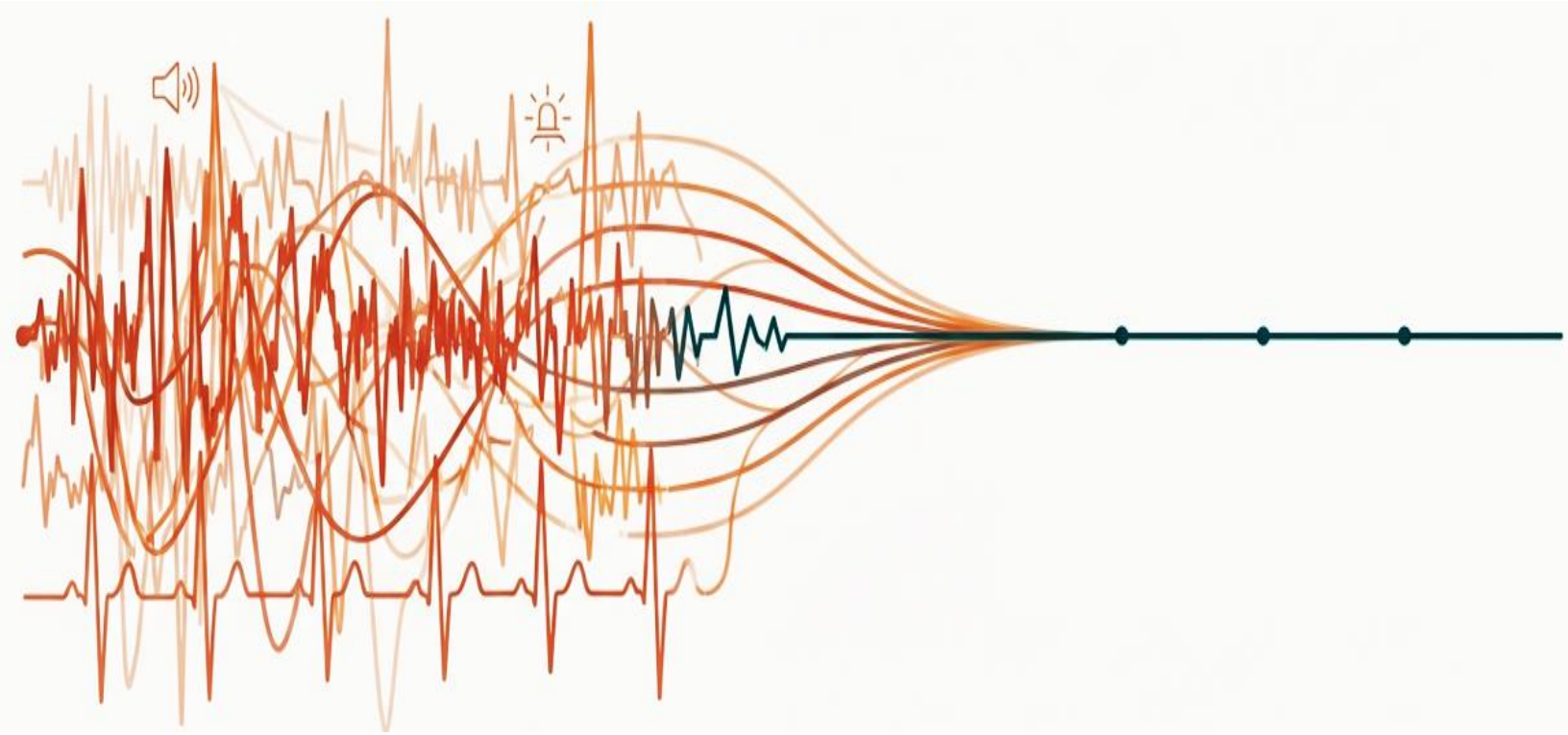
White Paper 2026

Precision Alarm Optimization with AlarmSense™

Impact on Alarm Burden and Clinical Perception



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Executive Summary

Alarm fatigue is a well-documented threat to patient safety and clinician performance in monitored hospital environments, driven by a high proportion of non-actionable physiologic monitor alarms that contribute to excessive noise, workflow disruption, and desensitization to clinically meaningful alerts.

A data-driven alarm optimization initiative was implemented in a Cardiothoracic Intensive Care Unit (CTICU) using Nihon Kohden's AlarmSenseTM to reduce non-actionable alarms through targeted adjustment of monitor parameters. Baseline alarm data were analyzed to identify high-frequency, low clinical actionability alarms, and parameter modifications were developed in collaboration with clinical staff and engineering stakeholders.

Following implementation, objective alarm data demonstrated marked reductions across multiple alarm categories, including irregular heart rate (97%), non-sustained ventricular tachycardia (95%), desaturation (49%), apnea (33%), and SpO_2 alarms (10%), with reductions concentrated in alarm types previously identified as high-volume and low-value.

Clinician perception of alarm burden, assessed via pre- and post-implementation surveys, showed consistent improvements in perceived alarm overload, workflow interruptions, and ability to concentrate on patient care. Additionally, 70% of clinicians reported noticing a reduction in nuisance alarms, 82% reported improved awareness of clinically important alerts, and 76% reported perceived improvements in patient care and safety.

Extended analysis demonstrated an 85% reduction in total alarm time per bed-day, reclaiming approximately 3.1 hours of alarm-free time per bed per day, along with substantial decreases in average alarm duration for vital sign (85%), SpO_2 (91%), and arrhythmia (70%) alarms, indicating reductions in both frequency and temporal burden.

These findings demonstrate that targeted, data-driven optimization of monitor settings can reduce non-actionable alarm burden while improving the clinical signal-to-noise environment, with no significant adverse events reported, and represent a scalable strategy for improving alarm management and clinician experience in monitored care settings.

The better question isn't "Can we reduce alarms?" But rather

"Are our alarms still serving clinicians and patients the way we intend?"

Background

Alarm fatigue is a well-recognized patient safety concern in hospital environments that utilize continuous physiologic monitoring. Although monitors are intended to alert clinicians to changes in patient status, a large proportion of alarms are non-actionable and do not require clinical intervention. Excessive alarm frequency can lead to desensitization, delayed response times, and increased environmental noise.

Studies have shown that a substantial proportion of physiologic monitor alarms are false, technically invalid, or clinically insignificant. Drew et al. reported that 72% to 99% of alarms do not require clinical intervention, underscoring the magnitude of the problem in monitored units.[1] Excessive alarm burden contributes to workflow disruption, increased cognitive load, and reduced responsiveness to clinically meaningful alarms.

Alarm fatigue has been identified as a major safety issue by regulatory and patient safety organizations. The Joint Commission issued Sentinel Event Alert 50 and established alarm management as a National Patient Safety Goal, citing risks such as missed alarms and delayed responses.[2] Similarly, the Emergency Care Research Institute (ECRI) has consistently identified alarm hazards among the top health technology safety risks.[3]

In addition to safety concerns, alarm activity contributes significantly to environmental noise. Elevated noise levels in clinical settings are associated with clinician distraction, increased stress, and disruption to patient rest and recovery.[4] High alarm volumes can also interrupt clinical tasks and reduce clinicians' ability to focus on patient care activities.

Because many alarms originate from monitor parameters that are not optimized for the clinical context, targeted alarm management strategies have been proposed. These include adjustment of thresholds, modification of delay settings, and elimination of non-actionable alarm types. Prior studies have demonstrated that such interventions can reduce alarm frequency while maintaining patient safety.[5]

Despite the evidence of these studies, many healthcare organizations continue to experience high alarm burdens due to default monitor settings, inconsistent configuration practices, or lack of systematic alarm management processes. Evaluating

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[1] Drew BJ, Harris P, Zègre-Hemsey JK, et al. Insights into the problem of alarm fatigue with physiologic monitor devices. *Journal of the American College of Cardiology.* 2014;64(16):1692-1700.
[2] The Joint Commission. Sentinel Event Alert Issue 50: Medical Device Alarm Safety in Hospitals. Oakbrook Terrace, IL; 2013.
[3] ECRI Institute. Top 10 Health Technology Hazards for 2020. Plymouth Meeting, PA: ECRI Institute
[4] Konkani A, Oakley B, Bauld TJ. Reducing hospital noise: A review of medical device alarm management. *Biomedical Instrumentation & Technology.* 2012;46(6):478-487.
[5] Cvach M. Monitor alarm fatigue: An integrative review. *Biomedical Instrumentation & Technology*. 2012;46(4):268-277

both objective alarm reductions and clinician perception of alarm burden is therefore important when assessing the effectiveness of alarm management interventions.

Objectives

The objectives of this project were to:

- Perform a comprehensive analysis of all bedside monitor alarm messages
- Determine the frequency and types of alarms to identify patterns and trends
- Identify false and non-actionable alarms that contribute to alarm fatigue
- Analyze changes based on data to better match patient needs and reduce unnecessary alarms

Methods

Project Design and Setting

This project was conducted as a quality improvement initiative within the MaineHealth system in a 16-bed CTICU. AlarmSense operates on Nihon Kohden's Digital Health Platform™ (DHP), which provides the required device-agnostic data collection, storage, and streaming infrastructure. Through this integration, alarm messages from the unit's Philips monitors were captured, normalized, and made available for analysis within AlarmSense.

The project included three phases: baseline alarm data analysis, clinical review and intervention development, and post-intervention evaluation.

Phase 1: Baseline Alarm Data Analysis

Objective alarm data were collected over a 6-month pre-intervention period using the AlarmSense platform. Alarm data were aggregated and analyzed to characterize:

- Overall alarm frequency
- Distribution of alarm types
- High volume alarm categories
- Patterns suggestive of low clinical actionability

This analysis was used to identify alarm types that contributed disproportionately to overall alarm burden.

Phase 2: Clinical Review and Intervention Development

Findings from the baseline alarm analysis were reviewed in a multidisciplinary setting with nursing and physician leadership, as well as clinical engineering. These discussions were used to contextualize objective alarm data with frontline clinical

experience, including how alarms were interpreted in practice, their perceived clinical relevance, and the frequency with which they resulted in clinical action.

Particular focus was placed on identifying alarm types that generated high volumes but were infrequently actionable, as well as understanding variability in how alarms were managed across clinicians and shifts. Clinical engineering input ensured that any proposed changes were technically feasible, aligned with device capabilities, and consistent with safe monitoring practices.

Based on the combined objective analysis and clinical input, five targeted recommendations were developed to modify alarm parameters associated with high-volume, low clinical actionability alarms. These recommendations included adjustments to alarm thresholds and arrhythmia detection parameters. Each proposed change was evaluated by the multidisciplinary team for its potential to reduce nuisance alarms while preserving the detection of clinically significant events.

This structured, multidisciplinary review process ensured that parameter adjustments were both data-driven and clinically validated prior to implementation.

Phase 3: Post-Intervention Evaluation

Objective Alarm Data

Following implementation, alarm data was collected for a 3-month post-intervention period using the same AlarmSense platform. Data definitions and collection methods were consistent across pre- and post-intervention periods.

Alarm frequency in each of the five targeted changes was compared between pre-and post-intervention periods. The primary outcome measure was the percentage reduction in alarm counts by alarm type.

Staff Perception Survey

To assess clinician perception of alarm burden, a pre- and post-intervention survey was administered to nursing staff.

The survey consisted of Likert-scale questions evaluating:

- Noise from unnecessary alarms
- Interruption of patient care
- Impact on concentration
- Perceived alarm overload
- Workflow disruption due to nuisance alarms

Responses were recorded using a five-point Likert scale with 49 responses collected pre-intervention and 29 responses collected post-intervention.

The post-intervention survey also included additional questions assessing staff perception of the intervention including:

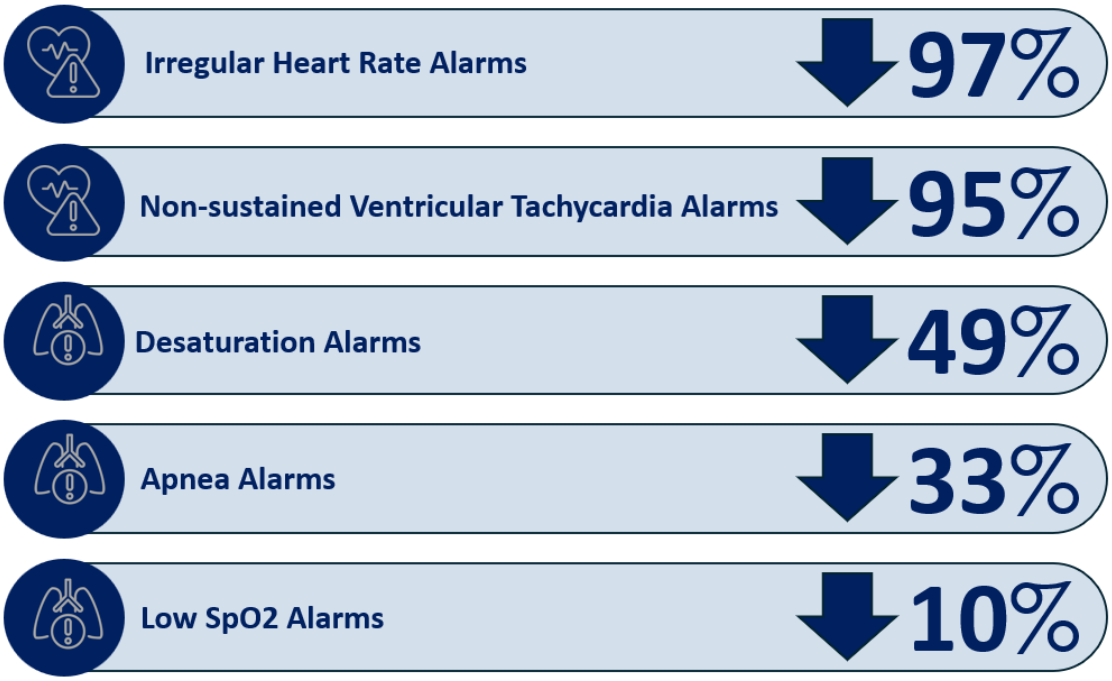
- Awareness of reduction in non-actionable alarms
- Perceived improvement in signal-to-noise ratio
- Perceived impact on patient care

Results

Objective Alarm Outcomes

Analysis of alarm data demonstrated substantial reductions in multiple high-volume alarm categories following implementation of targeted monitor setting adjustments.

The following reductions in alarm event counts per bed-day were observed:

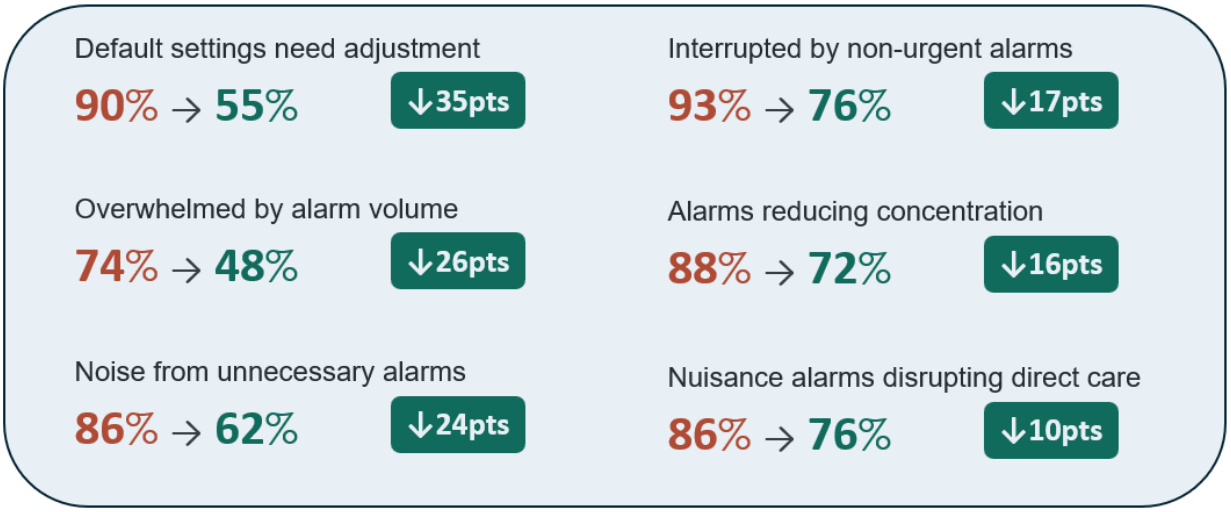


The most pronounced reductions were observed in arrythmia-related alarms, which historically represent a significant source of nuisance alarms. This resulted in a 50% reduction in overall arrhythmia alarms.

These findings indicate that the intervention was particularly effective in reducing alarm types previously identified as high-frequency and low clinical actionability.

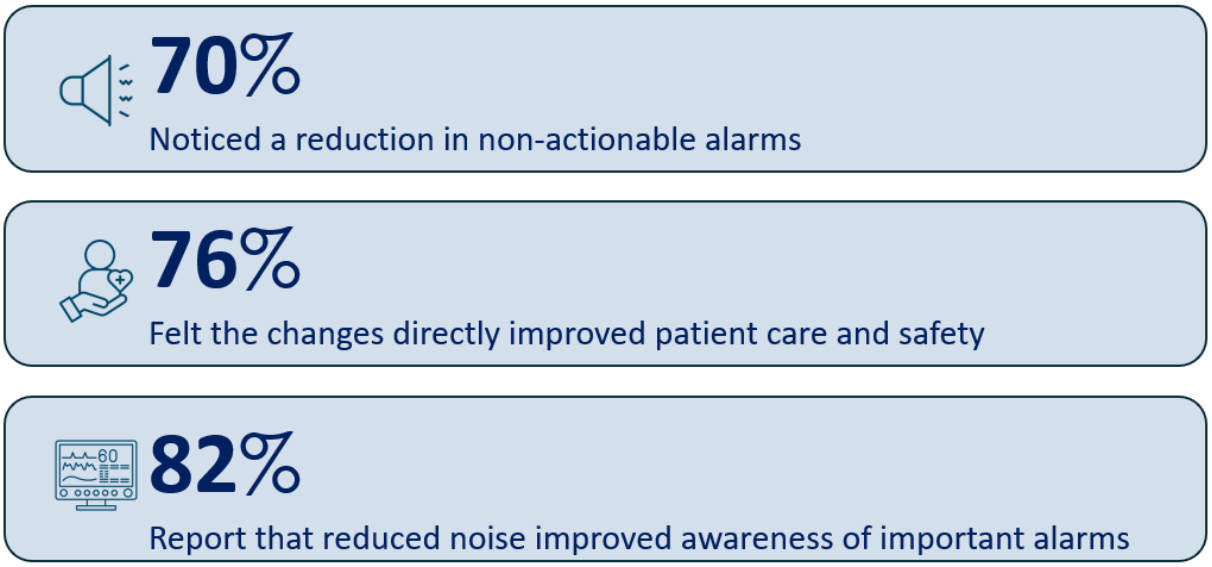
Staff Perception of Alarm Burden

Pre- and post-intervention survey data demonstrated consistent improvements in nurse-reported alarm burden across all assessed domains. Agreement rate (agree + strongly agree combined) for each survey item are presented below:



Staff Perception of the Intervention

Three questions were added to the post-intervention survey to directly evaluate nurse perceptions of the interventions. Survey responses indicated that a majority of clinicians perceived a meaningful change in the alarm environment:

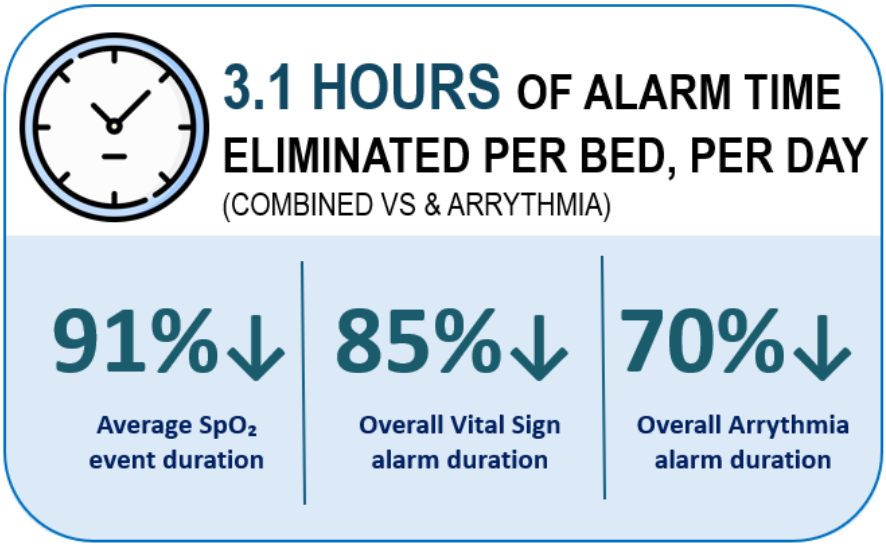


Alarm Event Duration Analysis

The observed improvements in clinician perception were supported by substantial reductions in objective alarm burden. When vital sign and arrhythmia alarms were evaluated in combination, total alarm time decreased from 13,147 to 1,944 seconds per bed per day, representing a reduction of 11,203 seconds (85%).

This corresponds to approximately 3.1 hours of alarm time eliminated per bed per day. These findings indicate that the intervention not only reduced the frequency of non-actionable alarms but also significantly decreased their cumulative duration, resulting in a meaningful reduction in overall alarm exposure.

The magnitude of this reduction provides a quantitative explanation for the reported improvements in clinician experience, including reduced perceived alarm overload, fewer workflow interruptions, and improved ability to focus on patient care.



Alignment of Objective and Perceived Outcomes

Reductions in objective alarm frequency were directionally consistent with improvements in clinician-reported alarm burden. The largest reductions in alarm counts occurred in arrhythmia-related alarms, which corresponded with substantial improvements in perceived alarm overload and concentration disruption.

While objective reductions in certain alarm categories exceeded 90%, clinician perception of improvement was more moderate, with approximately 69% of respondents reporting a noticeable reduction in nuisance alarms. This difference likely reflects variability in individual exposure to alarms and the multifactorial nature of alarm fatigue.

Together, these findings demonstrate that targeted, data-driven alarm optimization can substantially reduce non-actionable alarm burden while improving clinician experience.

Discussion

This project demonstrated that targeted, data-driven optimization of patient monitoring parameters can substantially reduce non-actionable alarm burden while improving clinician perception and awareness within the monitoring environment. The intervention resulted in large reductions in several high-frequency alarm categories, particularly arrhythmia-related alarms, alongside consistent improvements in staff-reported alarm burden. These reductions were achieved without reported adverse clinical effects, confirming that a substantial proportion of alarms were non-actionable.

Impact of Targeted Alarm Optimization

The most significant reductions were observed in irregular heart rate and non-sustained ventricular tachycardia (NSVT) alarms, which decreased by 97% and 95%, respectively. These alarm types are commonly associated with high frequency and low clinical actionability, and their reduction suggests that default or non-optimized monitor settings can contribute substantially to alarm burden.

The ability to achieve large reductions in these categories without reported adverse effects supports the conclusion that a meaningful proportion of alarms can be safely reduced through parameter optimization. This finding is consistent with prior literature demonstrating that many physiologic monitor alarms are non-actionable and that targeted configuration changes can reduce alarm frequency without compromising patient safety.

Clinical Awareness

Post-intervention survey responses indicated that a majority of clinicians perceived improved awareness of clinically important alarms. This suggests that the intervention improved the signal-to-noise ratio of the monitoring environment, a central goal of alarm management strategies.

Reducing non-actionable alarms may enhance clinicians' ability to identify and respond to clinically meaningful events by decreasing background noise and cognitive distraction. While this project did not directly measure response times or clinical outcomes, the observed improvements in perceived awareness are consistent with this mechanism.

Role of Data-Driven and Clinically Informed Design

A key strength of this initiative was the integration of objective alarm data with frontline clinical input. AlarmSense enabled identification of high-volume alarm types, while engagement with nursing staff and clinical engineering ensured that setting adjustments were clinically appropriate and operationally feasible.

This collaborative approach likely contributed to both the effectiveness of the intervention and its acceptance by clinical staff. Alarm management initiatives that rely solely on technical adjustments without clinical engagement may be less effective or less sustainable.

Considerations

This project was conducted within a single health system and may not be generalizable to all care settings. The pre- and post-intervention surveys included different sample sizes, and responses were based on self-reported perceptions, which may be subject to response bias. Additionally, the project did not directly measure patient outcomes or alarm response times, limiting conclusions regarding clinical impact.

The observational design also limits the ability to attribute all observed changes solely to the intervention, as other factors may have influenced alarm frequency or staff perception during the study period.

Implications for Practice

These findings support the implementation of structured, data-driven alarm management programs that move beyond reliance on default monitor settings. In this project, targeted optimization of a small number of high-volume, low-actionability alarms resulted in substantial reductions in overall alarm burden, demonstrating that meaningful improvement can be achieved without broad system changes.

Effective alarm management programs should leverage:

- Routine analysis of alarm data to identify high-frequency alarm types that contribute disproportionately to alarm burden
- Prioritization of low clinical actionability alarms, particularly those generating large volumes without requiring intervention
- Targeted parameter optimization, rather than global alarm suppression, to preserve clinically meaningful alerts
- Multidisciplinary collaboration between clinical staff and clinical engineering to ensure changes are both clinically appropriate and operationally feasible

Importantly, this approach is inherently scalable and deployable across hospital units requiring continuous or near-continuous monitoring. By focusing on a limited set of high-impact alarm categories, healthcare systems can achieve substantial reductions in alarm burden while improving clinician experience and the effectiveness of physiologic monitoring.

Conclusion

Targeted, data-driven optimization of physiologic monitor settings, informed by analysis using the AlarmSense™ platform, was associated with substantial reductions in non-actionable alarm frequency, including greater than 90% reductions in key arrhythmia alarm categories, and measurable improvements in clinician perception of alarm burden. These findings demonstrate that systematic identification and prioritization of high-volume, low-actionability alarms can meaningfully improve the signal-to-noise ratio of the monitoring environment.

Importantly, these improvements were achieved through a limited number of targeted parameter adjustments derived from objective alarm analytics and validated through frontline clinical input. The use of AlarmSense™ enabled efficient identification of high-impact alarm categories and supported a structured, data-driven approach to alarm optimization.

This approach represents a practical and scalable strategy for reducing alarm fatigue, improving clinician experience, and enhancing the effectiveness of patient monitoring in acute care settings.