Alarm Fatigue

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17.1 Introduction

Alarm fatigue is described as the reactionary effect that occurs when clinical staff or healthcare providers unavoidably experience an increased amount of alarms. Alarm fatigue can further be described as a causative response which arises due to sequential alarms of clinical equipment in the healthcare setting. Alarm fatigue occurs when clinical staff or healthcare providers become desensitized as a result of the overwhelming amount of alarms, real or false.

Clinical alarms are installed in most medical equipment utilized in the healthcare setting today. Common medical equipment includes cardiorespiratory monitors, pulse oximetry, capnography, ventilators, fall alarms, patient warming equipment, hypothermia equipment, and infusion pumps including intravenous and feeding pumps. In providing care to patients, multiple pieces of medical equipment are utilized increasing the risk of alarm fatigue and creating confusion in determining the device alarming [1]. Clinical staff may not prioritize alarm responsiveness appropriately due to the confusion created by multiple alarms.

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17.2 Purpose of Alarms

Clinical monitors are utilized in healthcare settings to provide care and continuous monitoring of a patient. Clinical monitors are designed to provide constant oversight to the patient's physiological state. Clinical alarms in medical devices are designed to alert clinical staff and healthcare providers by means of cognitive distress to physiological changes in the patient's medical state or systems errors within the clinical monitor. Clinical staff and healthcare providers experience both audio and visual cognitive recognition to clinical alarms. The alarms are meant to alert clinical staff or healthcare providers to address any changes identified by the alarm based on alarm settings.

17.3 Alarm Settings

Clinical alarms are preliminarily programmed by device manufacturers based on medical algorithms. Algorithms utilize a conservative approach to alarms in order to decrease risk and liability related to patient harm from a missed physiological change or system error [2]. Alarm algorithms are driven and developed by multifaceted events including human, organization, and technical factors. Standards for alarms are set by national governing bodies including the International Electrotechnical Commission (IEC,

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available at https://www.iec.ch) and the American National Standards Institute (ANSI, available at https://www.ansi.org) [3].

Levels of alarms vary based on predetermined factory settings or parameters. The most common alarm levels include crisis, warning, advisory, message, and system warning [4]. The predetermined levels alert clinical staff and healthcare providers based on the severity of the alarm identified by the medical device. Predetermined levels utilized include medical device manufacturer settings, organizational settings, unit-based settings, or individualized patient settings. Alarm tones vary based on equipment type, manufacturer, and organization settings. For the focus of alarm fatigue, clinical alarms can be further separated into non-actionable or nuisance alarms and actionable alarms [5].

17.4 Scope of Problem

Clinical staff and healthcare providers may experience between 350 and over 900 alarms per day [2, 3]. Components of alarm fatigue are alarm desensitization related to overload and delayed responsiveness and alarm apathy directly driven by a lack of trust in alarms [6]. The ECRI Institute has cited alarm hazards in their Top 10 Hospital Health Technology Hazards for 2019 which includes "Improper Customization of Physiologic Monitor Alarm Settings May Result in Missed Alarms" [7].

17.4.1 Non-actionable Alarms

Alarm fatigue typically occurs when the amount of non-actionable or nuisance alarms are prevalent causing clinical staff or healthcare providers to have decreased reactivity [8]. Studies have shown between 72% and 99.4% of alarms are non-actionable or nuisance alarms [4, 8, 9]. High percentages of non-actionable alarms increase the probability of clinical staff and healthcare providers delaying response or failing to respond to clinical alarms. Non-actionable or nuisance alarms are designed to create an awareness not requiring clinical staff or healthcare provider action or represent an invalid alarm. Alarm fatigue is a direct result of non-actionable or nuisance alarms.

17.4.2 Actionable Alarms

Actionable alarms are small in comparison to non-actionable or nuisance alarms. Approximately 10% of alarms occurring are actionable [4, 8, 9]. Actionable alarms require clinical staff or healthcare providers to intervene, address, and treat based on alarms occurring. Actionable alarms may be patient dependent and can be categorized in levels from crisis to message [4].

17.5 Response to Alarms

Clinical staff and healthcare providers respond to alarm fatigue utilizing measures directly impacting patient safety. Examples include failure to respond to alarms, silencing alarms, decreasing alarm volumes, setting inappropriate alarm parameters, or turning alarm parameters off [3]. Patients and clinical staff suffer when a failure to address actionable alarms occur as a result of alarm fatigue. The first sentinel event published by the ECRI Institute occurred in 1974 and was related to a hypothermia machine alarm resulting in patient burns [9]. Since 1974 The Joint Commission (TJC) has released sentinel events related to alarm fatigue. The most recent release spanned 3 years and included 98 events with 80 of those events leading to patient death [10]. In January 2019 TJC Hospital National Patient Safety Goals included *Goal 6: Reduce the harm associated with clinical alarm systems* [10]. Nursing personnel are overwhelmed with multiple healthcare noises including pagers, phones, healthcare personnel calling for assistance, patient call bells, and overhead paging. In addition to healthcare noises, nurses face additional challenges of interruptions by other healthcare personnel which may cause further overload and a delay in response to alarms. The culture set within the organization can directly impact alarm fatigue—addressing interruptions should be set within the organizations culture.

17.6 Impact of Alarm Fatigue

Alarm fatigue has a direct impact on the patient and the clinical staff or healthcare provider. Research has shown negative impacts on care provided and satisfaction related to alarm fatigue. The occurrence of negative outcomes and a poor provision of care can be directly correlated to alarm fatigue in the setting of increased non-actionable or nuisance alarms. Cardiorespiratory monitoring equipment and intravenous infusion pumps are the most common equipment utilizing alarms that play a role in the prevalence of alarm fatigue.

Alarm fatigue has been studied on multiple levels focusing on clinical staff and healthcare providers. Alarm fatigue causes increased cognitive distress related to anxiety, burnout, and negative clinical outcomes due to the response, or lack thereof [1].

The patient also experiences negative impacts and outcomes related to the occurrence of alarm fatigue. Patient impacts may range from poor patient satisfaction to, in some cases, death related to missed clinical events [11]. Alarm fatigue impacts patients by causing cognitive distress, difficulty sleeping, and may lead to an increased length of stay [12]. Further, patients may experience delirium from increased alarms, physiologic distress, and weakened immune systems [3, 13, 14]. Patients suffer the consequences of alarm fatigue related to cardiac arrest, respiratory arrest, and death.

The Joint Commission released information on examples of patient impact related to alarm fatigue. Examples include the death of a 60-year-old man related to the lack of responsiveness to an apnea alarm and the cardiac arrest of a patient due to a lack of response to a cardiac alarm for over 75 min [15]. Additional data on alarm consequences related mechanical ventilation alarms showed out of 23 events 19 deaths occurred, 65% were related to alarms [16].

17.7 Occurrence of Clinical Alarms

Clinical alarms occur for a multitude of reasons. They are preset by the equipment manufacturer and further individualized based on the healthcare setting or patient. Specifically, clinical alarms driven by physiologic changes have the greatest variance in audio alarm settings. The most significant and actionable alarm is a *crisis alarm*. *Crisis alarms* are commonly programmed for arrhythmias including asystole, ventricular tachycardia, ventricular fibrillation, and ventricular bradycardia. *Warning alarms* are commonly set for tachycardia, bradycardia, and ventricular tachycardia non-sustained for greater than two beats. *Advisory alarms* are commonly set for pulse oximetry outside of normal limits and premature ventricular contractions. *Message alarms* are commonly set for couplets—regular or irregular. *System warnings* are commonly set for lead failures or arrhythmia suspend [4].

17.7.1 Etiology of Clinical Alarms

Common causes of clinical alarms related to the patient's physiologic state include poor lead placement or connection, dried electrocardiogram (ECG) electrodes, physiologic alarm parameters set with a small window of variance, and pulse oximetry monitors placed incorrectly [10]. Common causes of mechanical ventilation alarms include high pressure, low pressure, or disconnection alarms; this requires patient assessment to ensure the alarm is not patient condition related [17]. Common causes of infusion pump alarms can be divided into mechanical alarms or dosing alarms. Mechanical alarms are related to air in the line, occlusions, or low battery; dosing alarms are related to exceeding or not meeting standard dosing alarm limits [18].

17.8 Reducing the Prevalence of Alarm Fatigue

Alarm fatigue is the responsibility of the organizations leadership with a strict focus on the utilization of proper equipment alarms, development and implementation of policies, and staff education [19].

Reducing the prevalence of alarm fatigue remains a significant patient safety initiative. Clinical staff and healthcare providers are tasked

with addressing the safety concerns related to alarm fatigue and implementing practices to reduce the occurrence of alarms in the healthcare setting. Healthcare professionals should work closely with device manufactures to individualize alarm systems for clinical equipment.

Throughout the literature, healthcare professionals have shown positive impacts in patient safety initiatives related to alarm fatigue. The following is a review of practices related to clinical alarms shown to have successful outcomes in reducing the number of alarms which occur.

Utilizing an evidence-based approach to addressing alarm fatigue is imperative for patient and staff safety. Throughout the literature, evidence-based practice is being utilized to combat alarm fatigue. Recent literature identifies multiple approaches including daily electrode changes, proper skin preparation, eliminating non-actionable alarms, patient alarm customization, and alarm volume individualization [6, 20].

Smart alarms utilize variability in the patient's state to learn physiologic variances individualized to the monitored patient. This can be described when the patient-specific variances are identified by the equipment which then limits the occurrence of nuisance alarms while maintaining normal parameters for the patient [21]. Setting individualized, specific parameters which are patient based are imperative in reducing the prevalence of alarm fatigue. Alarm threshold settings should be customized based on the patient's condition, known normal, and prioritization of arrhythmias. Patient-specific conditions can set preliminary alarms which can be further individualized for each patient. Patient monitoring should be utilized in patients with specific indications [8].

Alarms should be set based on urgency and actionable response. Utilizing proper lead placement, proper probe placement, and increased amplitude in physiologic monitors can reduce the number of clinical alarms [8]. *Non-crisis* alarms may be programmed with a 6 s delay to allow for false readings to re-correct before alarming.

17.9 Staff Education on Alarms

Clinical staff and healthcare providers require education on the types of alarms, alarm reduction and prioritization, and equipment use impacting alarms. Organizations must work closely with equipment manufactures to ensure staff are properly trained on the types, levels, and acuity of alarms utilized in specific pieces of equipment. Staff should be educated on safe practices in alarm response, established protocols or practices for response, and documentation of alarm parameters [3] (Fig. 17.1). A recent study on nursing staff and alarm fatigue provided insight, validating most nursing staff are not aware of the scope of the problem or the level of alarm fatigue suffered [19].

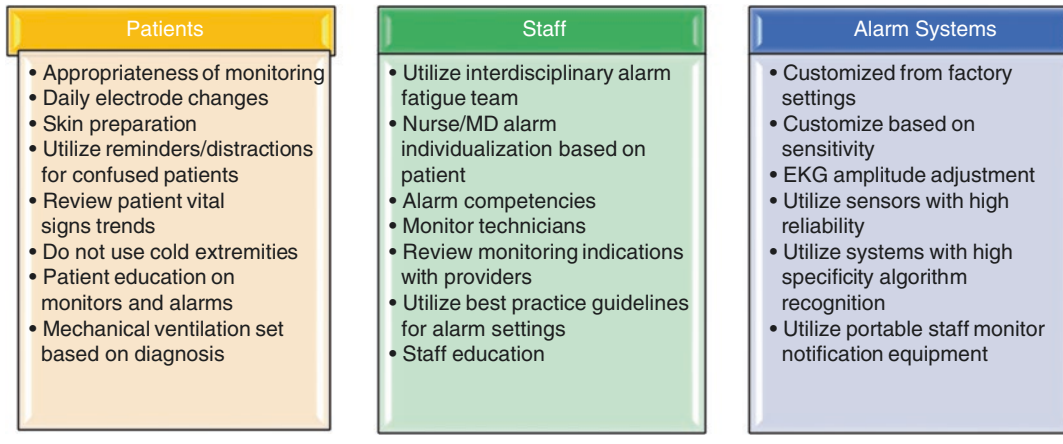

Fig. 17.1 Alarm reduction education. Additional information for staff education can be found at the Association for Advancement of Medical Instrumentation (AAMI, available at www.aami.org/htsi/alarms) [22]

17.10 Conclusion

In conclusion, clinical alarms are developed and implemented for patient safety, clinical staff safety, and a prevention method to life-threatening outcomes. Due to the potential life-threatening impacts, addressing and implementing initiatives to combat alarm fatigue is essential.

Utilizing a multimodal approach to addressing alarm fatigue can be the most effective and have significant positive impacts on outcomes. Alarm fatigue must be a top priority in patient safety and organizational outcomes.

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