Archives of Anesthesiology and Critical Care (Autumn 2025); 11(4): 585-595.

Available online at http://aacc.tums.ac.ir

Review Article

# What Are the Most Common Ventilator Alarms in the ICU? An Integrative Review

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**ARTICLE INFO**

**Article history:**
Received 03 December 2024
Revised 25 December2024
Accepted 09 January 2025

**Keywords:**
Critical care;
Artificial respiration;
Auditory fatigues;
Nursing

**ABSTRACT**

**Background:** Considering the vital role of the mechanical ventilator in providing respiratory support to patients, it is important and necessary to pay attention to and identify the common alarms of this device and to sensitize the medical team to these warnings.

**Methods:** This integrative review study was conducted in order to evaluate both printed and non-printed studies. Searching was done from 20/09/2010 to 20/09/2023 based on Prisma 2009 guidelines in Scopus, PubMed, Embase, and ProQuest databases. The keywords included "pulmonary ventilator," "mechanical ventilators," "ventilator," "respirators," "alarm," "clinical alarms," and "alarm fatigue," and the articles were selected based on the entry criteria

**Results:** Out of a total of 264 retrieved articles, 13 articles were included in the study. The obtained results indicated that the most frequent alarms were High PIP, High RR, and High/Low MV, which are not only important alarms, but also have high prevalence in the intensive care unit. Therefore, great attention should be paid while setting the alarm range and reacting to auditory and visual alarms.

**Conclusion:** Failure to pay attention to alarms and setting them improperly has a significant effect on the medical team's fatigue, which leads to a decrease in the quality of care. Therefore, using a correct management strategy in order to increase the medical team's knowledge and reduce unnecessary alarms can play an effective role in improving the quality of the services provided to the patients hospitalized in special care units. Identifying the important alarms of mechanical ventilators and using the appropriate strategy to set the alarms correctly can increase the quality of the care provided for the patients under mechanical ventilation.

## Introduction

A mechanical ventilator is among the most important and widely used medical equipment in special care units, which plays a vital role in patients' survival [1-2]. Due to the important role of this machine in patients' conditions, paying attention to the warnings of this machine is of great importance. Alarms or warnings have been designed with the aim of notifying nurses and physicians of the changes in the patient's condition and are announced by the machine in both auditory and non-auditory forms [1, 3].

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DOI: 10.18502/aacc.v11i4.19379

The alarms announced by the machine have different degrees of importance; some of them require taking action, but some do not require specific actions on the part of the caregivers [3-4]. The results of a study indicate that only 2.26% of all the alarms generated by the device required intervention by physicians or nurses [5]. Other studies have also shown that about 85–99 percent of machine alarms do not require staff intervention, while the number of ventilator alarms for each patient has been more than 150 [1-2].

Multiple alarms can cause a phenomenon called alarm fatigue or alarm desensitization, which is one of the challenges of patient safety in the special care unit and has become one of the most important concerns in recent years [4, 6]. Alarm fatigue, as a clinical situation, is a concept in which an individual becomes desensitized to real alarms due to false alarms and does not respond appropriately [7-8]. Decreased nurse responsiveness and slow response time to alarms are among the potentially dangerous consequences that occur due to the multiplicity of announced alarms, the frequency of alarms, and unnecessary warnings [4, 9].

Owing to the importance of the phenomenon of alarm fatigue in the occurrence of dangerous accidents and patient mortality, some studies have been conducted in order to investigate common alarms in the intensive care unit in recent years [9]. In a review study conducted in 2019, Scott et al. have examined the reported alarms of mechanical ventilators. The findings of their study focus on describing the problem, the challenges related to alarm limit settings, the problems related to auditory alarms, the negative impact of sounds, and the factors related to alarm fatigue [1].

Another review study conducted in 2020 has investigated the use of mechanical ventilators' alarms in various papers. This study states that the management of mechanical ventilators' alarms can be done through targeted training, determining standard policies, and conducting further studies [2].

Other studies conducted in this field have investigated alarms in intensive care units from different aspects, such as the number of alarms, nurses' responses, and the alarms' degrees of importance. However, in the field of common alarms in intensive care units, there is no consensus of opinion, and so far, no study has been done that examines the available evidence systematically and criticizes and evaluates it. Thus, this research was conducted through a systematic review approach with the aim of knowing common ventilator alarms so that, according to the results, practical suggestions can be made for better setting and management of ventilator alarms and providing safe mechanical ventilation.

### Aims

Critical review of the studies on different types of ventilator alarms in intensive care units.

## Methods

### Study Design

This integrative review study was conducted through a systematic search in order to evaluate both published and non-published studies related to common ventilator alarms. The search procedure was performed based on the guidelines of Prisma 2009.

### Sources of Data Collection

Searching for literature was done from 20/09/2010 to 20/09/2023 in the English databases, including Scopus, PubMed, Embase, and ProQuest, using combinations of the keywords "Pulmonary Ventilator," "Mechanical Ventilators," "Ventilator," "Respirators," "Alarm," "Clinical Alarms," and "Alarm Fatigue," as well as Boolean or the shortcut keys AND, OR, and NOT. Respectively, 27, 59, 70, and 108 articles were searched in the mentioned databases, and a total of 264 articles were searched (Appendix 1). Hand search was also performed in the Google Scholar search engine, key journals, and the sources of the key and relevant articles, and 11 articles were obtained. A literature search was done by two authors separately, and the final list of the obtained articles was shared. In order to organize the studies, EndNote information resource management software was used. After the initial search of the extracted studies, the articles were selected based on the inclusion criteria.

### Inclusion Criteria

All the studies conducted on ventilator alarms, which obtained the minimum score of articles' methodological quality assessment tool and whose full texts were available, were included in the study. Regarding the articles whose full texts could not be accessed, the responsible author was contacted via email or, if possible, by phone to access the full texts, and, finally, the articles were officially purchased from the databases.

### Exclusion Criteria

Letters to editors and conferences were excluded from the study due to not using primary data, the presentation of abstracts orally or as posters, the lack of access to the original article, or the methodological information of the article.

### Articles' Quality Assessment Tool

The quality assessment of the articles was done by the research team based on the study approach and using the specialized and standard checklists of the Joanna Briggs

Institute depending on the approach of each study. The tools introduced to evaluate articles by the Joanna Bridges Institute are standard and have been used in many studies [10]. The quality of the final articles was evaluated separately by two researchers with experience in the field of systematic review research. Then, in a joint meeting, the results were discussed, and in cases where there was disagreement, the discussion continued until the research team reached a final agreement.

## Results

Out of 264 primary articles extracted from databases and 11 studies extracted based on manual search, a total of 275 studies were in line with the research objective. After the primary screening (the review of abstracts), 90 studies were included, and in the second screening (studying the full texts of the articles) and based on the purpose and the design of the study, the final results, the determined inclusion and exclusion criteria, and the type and the method of reporting the prevalence of ventilator alarms in the intensive care unit, in accordance with the 2009 Prisma pattern, finally, 13 studies were extracted (Figure 1).

All the 13 studies were related to the prevalence of ventilator alarms in special care units in terms of the purpose, final results, and environment under assessment; the most attention was paid to the evaluation and the management of alarms based on the results obtained between 2018 and 2020. All the 13 final studies obtained were examined through specialized review tools (PRISMA, STROBE, and QI-MQCS), and all had acceptable quality to enter the final evaluation stage. The studies have been sorted based on the pyramid of evidence, from the highest to the lowest level of evidence (Figure 1).

The objectives of evaluating ventilator alarms in all the selected final articles were mostly in line with the following goals: 1. Investigating the frequency of common alarms, 2. the fatigue caused by the experience of repeated alarms, 3. identifying and controlling alarms in order to provide appropriate supportive ventilation for patients, 4. determining alarm management policies, 5. comparing the effect of personnel response to visual and auditory alarms, and finally, 6. evaluating the variables influencing the management of ventilator alarms [1, 5, 11-20].

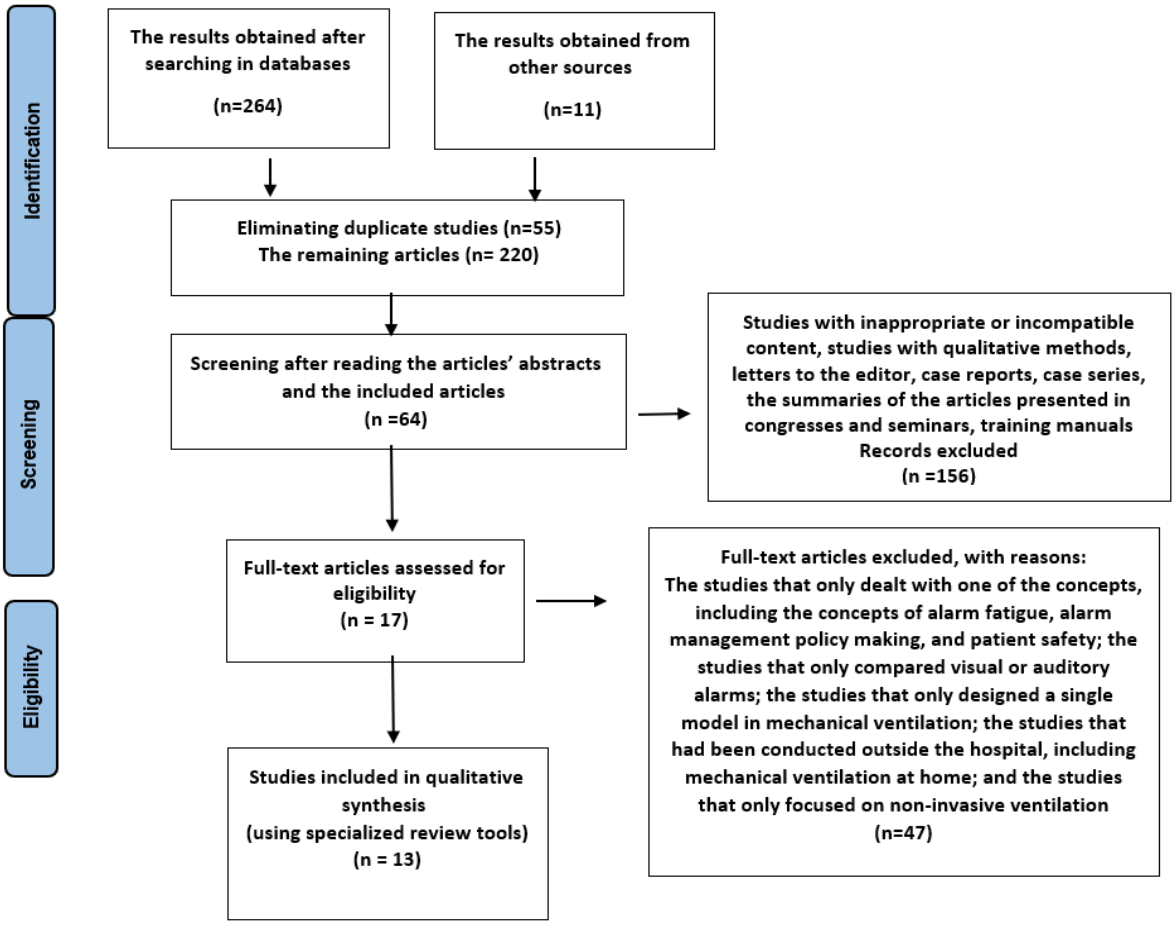

**Figure 1- The pattern of including studies based on Prisma 200**

Furthermore, most studies [1, 11-13, 15-20] had investigated the prevalence of the most frequent ventilator alarms in adult intensive care units, two studies [5, 14] in neonatal intensive care units, and one study in a pediatric intensive care unit [9].

The most common ventilator alarms reported in intensive care units were the following: In the first study, the peak inspiratory pressure (PIP) with a frequency of 34.3% and the respiratory rate (RR) with a frequency of 17.8% [1], in the second study, PIP [11]; in the third study, PIP and RR [12]; in the fourth study, RR with a frequency of 28% and PIP with a frequency of 22% [13]; in the fifth study, PIP [5]; in the sixth study, respectively, RR and MV (Minute Volume) [14]; in the seventh study, five alarms: HI.PIP/HI.RR/HI/LOW MV/Leakage/HI PEEP [15]; in the eighth study, high peak airway pressure (HPAP) alarm [16]; in the ninth study, Low TV and high pressure alarms [17]; and, in the tenth study, PIP, RR, and HIGH/Low MV [18], in the eleventh study Inspiratory flow, High airway frequency and High pressure [9], in twelfth study, low minute ventilation and high respiratory rate [19] and last study, inspiratory and expiratory tidal volume and positive end-expiratory pressure (Table 1).

In all these 13 studies, pressure alarms were reported more frequently than volume alarms, and the three most common alarms reported included high pressure, high respiratory rate, and high/low minute volume. Out of these 13 studies, 10 (the majority of studies) [1, 5, 9, 11-13, 15-18] have introduced the high-pressure alarm as a common ventilator alarm. Eight studies [1, 9, 12-15, 18-19] have introduced High Respiratory Rate Alarm as one of the three common alarms, and in 4 studies [14-15, 18-19], Minute Volume or minute ventilation volume were among the 3 common alarms. Among the 4 common alarms, five studies [1, 11-12, 16, 18] have identified PIP, and two studies [13-14] have identified RR as the most common alarm. In adult intensive care units, PIP and RR were the most common alarms, and in neonatal intensive care units, in addition to the two aforementioned alarms, the MV volume alarm was also reported as one of the most common.

**Table 1- The objectives of evaluating ventilator alarms**

| Author/year | Country | Aim | Methodology | Critical appraisal tools | Setting | Out come |
|---|---|---|---|---|---|---|
| 1. J Brady Scott, Laura De Vaux, 1. Connie Dills, and Shawna L Strickland 2019 [1] | USA | To examine and report on the literature that pertains to mechanical ventilation alarms and alarm fatigue and to propose recommendations for future research | Literature review | PRISMA[1] | ICUs | The most common ventilator alarm Peak Inspiratory Pressure[2] (34.3%) and the second most common alarm: Increased Breathing Frequency (17.8%), |
| 2. Elisavet, Koutsiana, Achilleas Chytas, Katerina Vaporidi and Ioanna Chouvarda, 2019 [11] | Greece | focus on alarms in the intensive care unit and especially on the use of machine learning techniques for the creation of alarms for the ventilator support of patients | Interventional study | QI-MQCS[3] | ICU | The most common ventilator alarm End-Inspiratory Pressure(Plateau pressure)[4] |
| 3. Maria M. Sajid H. Manzoor, Patrick O. Brooks,Timothy S. Burger, Allan Gottschalk Aliaksei Pustavoitau, 2018 [12] | USA | To determine the frequency of ventilator alarms | Observational Study | STROBE[5] | 3 adult ICUs | The most common ventilator alarm High inspiratory pressure[2] and the second most common alarm: High respiratory rate |

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|---|---|---|---|---|---|---|
| 4. Karsten J. Roberts, Steven W. Gudowski and Margie Pierce 2018 [13] | USA | To department policy of mechanical ventilator alarms | Observational Study | STROBE | ICU | The most common ventilator alarm High respiratory rate 28%. High peak inspiratory alarm [2] 22% |
| 5. Z. K. Lin1, K. Zheng1*, Y. M. Shen1, C. X. Zheng1, Y. Y. Wu1, X. Y. Cheng1. 2018 [5] | China | To evaluated the alarm situation synthetically through investigation and statistical methods. | Observational Study | STROBE | NICU | The most common ventilator alarm High inspiratory pressure |
| 6. Gusztav Belteki, Colin J Morley. 2017 [14] | UK | To investigate the frequency and cause of neonatal ventilator alarm | Observational Study | STROBE | NICU | The most common ventilator alarm respiratory rate alarm Minute volume alarm |
| 7. Weirauch, Andrew; Culter, Christopher; Loik, Paul; Andrews, Allan; Barnes, Brian; Cusac, Jessica; Eakin, Richard; Fecteau, Kimberly; Haas, Carl F. 2016 [15] | USA | To determine which alarms trigger most often, whether they are adjustable, and their level of priority. | Observational Study | STROBE | ICU | Five common alarms including High Peak Inspiratory Pressure[2] (HI.P) PIP/ High respiratory rate. / High/Low Minute volume alarm[6] / Leakage/ High PEEP |
| 8. Covert T, Niu NT. 2015, [16] | USA | To describe the basics of respiratory mechanics that contribute to HPAP | Observational Study | STROBE | ICU | The most common ventilator alarm High peak airway pressure (HPAP)[2] alarm |
| 9. Soheila Mojdeh, Ali Reza Sadri, MohammadMehdi Nabii,Hossein Emadian, Mojtaba Rahimi, 2010 [17] | IRAN | To compare the response times to “vocal alarms” and “visual or audible ones”. | Observational Study | STROBE | ICU | The most common ventilator alarms Low exhaled Tidal Volume High pressure limit[2] |
| 10. Kristina D Ramirez, Victoria D Soucy, Hassan Alghareeb, Maricella Chavez, Megan McLin, Annie Tran, Megan Carrion, Thomas Stokes, Richard Wettstein and Ruben D Restrepo, 2019 [18] | USA | To evaluate ventilator alarm parameters | Descriptive Study | STROBE | ICU | The most common ventilator alarms High peak inspiratory alarm Respiratory rate alarm High/Low Minute volume alarm |

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|---|---|---|---|---|---|---|
| 11. Leo Langga, Jisoo Oh, David Lo´pez, Nancy Blake, Edward McField, Justin Hotz, Leonardo Nava-Guerra, Kelby Knox, and Richard Chinnock, 2021 [9] | USA | To evaluate most common ventilator alarm and improving alarm management | Descriptive Study | STROBE | PICU | The most common ventilator alarms Inspiratory flow over range High airway frequency High pressure[2] |
| 12. C Yujen, C Shuhua, H Yaoch uan 2022 [19] | Taiwan | To determine the amount of time ventilators were alarm, but received no intervention. | Descriptive Study | STROBE | ICU | The most common ventilator alarms low minute ventilation high respiratory rate |
| 13. Jayant Giri 1,*, Hamad A. Al-Lohedan 2, Faruq Mohammad 2, Ahmed A. Soleiman 3, Rajkumar Chadge 1, Chetan Mahatme 1, Neeraj Sunheriya 1, Pallavi Giri 4, Dhananjay Mutyarapwar 5 and Shreya Dhapke. 2023, [20] | Switzerland | To evaluate most common ventilator alarm to determine the best machine learning method | Descriptive Study | STROBE | ICU | The most common ventilator alarms, That need to education inspiratory and expiratory tidal volume positive end-expiratory pressure[7] |

1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; 2: measures the force of inhalation generated by contraction of the diaphragm and is an index of the ability to maintain lung expansion and avoid atelectasis. 3: Quality Improvement Minimum Quality Criteria Set; 4: Plateau pressure (Pplat) is the end-inspiratory airway pressure and is measured just after airflow has ceased; 5: The Strengthening the Reporting of Observational Studies in Epidemiology; 6: This alarm will sound when the amount of air taken in per minute drops below a set value. 7: is a pressure applied by the ventilator at the end of each breath to ensure that the alveoli are not so prone to collapse.

## Discussion

In all studies, ventilator alarms have been considered one of the most common alarms in intensive care units, which can be an important part of clinical practice in care provision for the patients under mechanical ventilation [11, 21]. Although the alarms related to physiological monitoring have attracted much attention during the past 5 years, among the top 10 health technology hazards, ventilator alarms have been listed as the third greatest hazard, due to the unique challenges they pose for the care system [2, 22].

According to the studies conducted in special care units, the most common alarms include high pressure or peak inspiratory pressure (PIP) [1, 5, 9, 11-13, 15-18], respiratory rate alarm [9, 14-15, 18-19], and minute volume (high/low). Some studies [1, 11-12, 16, 18] have introduced PIP as the most common alarm, and others have mentioned RR. According to the results of the study by Weirauch et al. (2016), 60% of the alarms, in addition to the three main reported alarms, also included two alarms: Leakage and High PEEP. It seems that the results of this study have been influenced by the evaluation of alarms during interventions such as suctioning and bathing patients. Besides, the alarms have been evaluated using only one brand of ventilators [15].

The overabundance of alarms in a clinical setting is the largest contributor to alarm-related adverse events. These factors influence the caregiver's perception and response to mechanical ventilation and clinical alarms. Observing the response to the stimuli shows that the response to the alarms corresponds to the reliability and the perceived value of the alarm system [2]. According to the medical team, the most alarming devices at intensive care units are cardiac monitors, infusion pumps, and ventilators [3]. Nevertheless, many electronic devices used in patient care and a combination of alarms can cause sensory overload in caregivers. This sensory overload may cause fatigue in caregivers, and they may miss important alarms, which can be fatal for patients. Many factors unrelated to patients' condition changes can be directly

related to alert desensitization and fatigue, leading to failure to recognize or ignoring real instability despite alerting [23].

Alarm fatigue is a major risk to patient safety. The nurses who are exposed to a high rate of inoperable physiological monitor alarms respond to subsequent alarms more slowly, which can sometimes lead to life-threatening conditions for the patient [24]. Therefore, ignoring urgent warnings can endanger the patient's safety [9, 19, 25].

According to the conducted studies, among ventilator alarms, the auditory ones have the greatest impact on the alarm fatigue perceived by the medical team [1, 17]. Alarm fatigue has attracted attention not only in adult special care units but also in newborn special care units. The results of paying attention to this important issue can lead to not only the safety of newborns and children but also the satisfaction of their families [26-27].

As mentioned, alarm fatigue is considered one of the most critical ICU issues in clinical care systems, which has been given special attention due to its importance in hospital accreditation systems [3]. Nonetheless, according to the available reports, 26.8% of the alarms are minor, and only 2.26% of total alarms lead to the physician's intervention [5]. On the other hand, in special care units, 20 percent of alarms are adjustable by the user, but 80 percent are not [15]. Therefore, minimizing alarm fatigue is a challenging task [28], which raises the need for proper alarm management.

Therefore, the use of useful strategies and policies to manage alarms in special care units can be effective not only in controlling alarm fatigue but also in patient safety and the best service provision. Accordingly, studies have recommended several solutions: 1. Increasing physicians' knowledge of the purpose and the importance of alarms through holding courses and workshops and practical exercises [3, 28-29]. 2. More than half of the alarms had medium priority; therefore, our strategy should be aimed at reducing the frequency of alarms in intensive care units [3, 13]. 3. Reaching an agreement on a suitable strategy (safer ventilator alarms) [1] and common in setting alarm warnings [9] (Table 2).

**Table 2- The goals of ventilator alarm evaluation**

| Author/year | Title | Alarms frequency | Alarms fatigue | Patient safety | Alarms management policies | Best practice |
|---|---|---|---|---|---|---|
| 1. J Brady Scott, Laura De Vaux, 1. Connie Dills, and Shawna L Strickland, 2019 [1] | Mechanical Ventilation Alarms and Alarm Fatigue | No | yes | yes | No | No |
| 2. Elisavet, Koutsiana, Achilleas Chytas, Katerina Vaporidi and Ioanna Chouvarda, 2019 [11] | Smart alarms towards optimizing patient ventilation in intensive care: the driving pressure case | yes | No | No | yes | yes |
| 3. Maria M. Sajid H. Manzoor, Patrick O. Brooks,Timothy S. Burger, Allan Gottschalk Aliaksei Pustavoitau, 2018 [12] | Ventilator Alarms in Intensive Care Units: Frequency, Duration, Priority, and Relationship to Ventilator Parameters | yes | No | No | yes | No |
| 4. Karsten J. Roberts, Steven W. Gudowski and Margie Pierce, 2018 [13] | A Descriptive Analysis of Adherence to Ventilator Alarm Policy | No | No | yes | No | yes |
| 5. Z. K. Lin1, K. Zheng1*, Y. M. Shen1, C. X. Zheng1, Y. Y. Wu1, X. Y. Cheng1. 2018 [5] | Survey and Analysis of Current State of Ventilator Alarms in the Intensive Care Unit | yes | No | No | No | yes |
| 6. Gusztav Belteki, Colin J Morley.2017 [14] | Frequency, duration and cause of ventilator alarms on a neonatal intensive care unit | yes | yes | yes | No | No |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7. Weirauch, Andrew; Culter, Christopher; Loik, Paul; Andrews, Allan; Barnes, Brian; Cusac, Jessica; Eakin, Richard; Fecteau, Kimberly; Haas, Carl F. 2016 [15] | Frequency and priority level of ventilator alarms in the intensive care unit: Preliminary quality assurance study | yes | yes | yes | yes | No |
| 8. Covert T, Niu NT. 2015, [16] | Differential Diagnosis of High Peak Airway Pressures | yes | yes | yes | No | No |
| 9. Soheila Mojdeh, Ali Reza Sadri, MohammadMehdi Nabii,Hossein Emadian, Mojtaba Rahimi, 2010 [17] | Designing the Vocal Alarm and improving medical ventilator | yes | yes | yes | No | No |
| 10. Kristina D Ramirez, Victoria D Soucy, Hassan Alghareeb, Maricella Chavez, Megan McLin, Annie Tran, Megan Carrion, Thomas Stokes, Richard Wettstein and Ruben D Restrepo, 2019 [18] | Ventilator alarms selection in the ICU | yes | No | yes | No | yes |
| 11. Leo Langga, Jisoo Oh, David Lo´pez, Nancy Blake, Edward McField, Justin Hotz, Leonardo Nava-Guerra, Kelby Knox, and Richard Chinnock,2021 [9] | Prevalence, Proportionality, and Cause of Ventilator Alarms in a Pediatric Intensive Care Setting | yes | yes | yes | yes | yes |
| 12. C Yujen, C Shuhua, H Yaochuan, 2022 [19] | Ventilator alarms that received no intervention:an analysis of ventilator alarm relationship in intensive care unit | yes | yes | yes | No | No |
| 13. Jayant Giri 1,*, Hamad A. Al-Lohedan 2, Faruq Mohammad 2, Ahmed A. Soleiman 3, Rajkumar Chadge 1, Chetan Mahatme 1, Neeraj Sunheriya 1, Pallavi Giri 4, Dhananjay Mutyarapwar 5 and Shreya Dhapke. 2023, [20] | A Comparative Study on Predication of Appropriate Mechanical, Ventilation Mode through Machine Learning Approach | yes | yes | yes | yes | yes |

**Limitations**

One of the limitations of this study was the lack of access to the CINAHL database, due to researchers' lack of access to it in Iran. Therefore, an effort was made to extract the maximum number of studies conducted in this field by selecting more databases.

**Recommendations and/or Implications for Practice and/or Further Research**

It is suggested that future studies will pay attention to the identification of the barriers and the facilitators of recognizing ventilator alarms through designing qualitative studies or interventions to choose appropriate strategies for setting alarms.

## Conclusion

Based on the results obtained, the most frequent alarms include high PIP, high RR, and high/low MV. Only a small percentage of ventilator alarms require immediate intervention by a physician, while inappropriate alarm setting and the high frequency of unnecessary auditory alarms in special care units can have a significant impact on the level of alarm fatigue in the medical team and reduce safety, leading to a reduction in the level of

satisfaction in both the patient and the family. This will lead to a decrease in the quality of care; therefore, using an appropriate management strategy to increase the medical team's knowledge and reduce unnecessary alarms can play an effective role in improving the quality of service provision to the patients hospitalized in special care units.

**What is known about this topic and what this paper adds?**

- Recent studies have examined the frequency of alarms, how nurses respond, and the importance of alarms in intensive care units.
- The results of this study can help clinical nurses to set and better manage ventilator alarms and provide safe mechanical ventilation.
- The results of studies related to ventilator alarms in five important clinical and practical areas, including patient safety, alarm management policies, best practices, alarm fatigue, and alarm frequency, were evaluated.

### Ethical consideration

This study received approval from the Research Ethics Committee of Baqiyatallah University of Medical Sciences, Tehran, Iran, with the ethics code no. IR.BMSU.REC.1400.161.

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## Appendix

**Search strategy**

- **PUB MED**

| | |
|---|---|
| Q1 | Ventilators, Mechanical[TI] OR Pulmonary Ventilator[TI] OR Pulmonary Ventilators[TI] OR Respirators[TI] OR Ventilator[TI] OR Pulmonary Ventilators[TI] OR Ventilators[TI] OR Pulmonary Mechanical Ventilation [TI] OR Ventilation, Mechanical [TI] OR "Ventilators, Mechanical"[MH] OR "Ventilators, Mechanical"[TI] |
| Q2 | Alarm, Clinical[TI] OR alarm[TI] OR alarms[TI] OR alarm fatigue[TI] OR Alarms, Clinical[TI] OR Clinical Alarm[TI] OR "Clinical Alarms"[TI] OR "Clinical Alarms"[MH] OR common alarms[TI] OR important alarm[TI] OR common reasons[TI] |

| PUBMED | |
|---|---|
| Search ((((Ventilators, Mechanical[AB] OR Pulmonary Ventilator[AB] OR Pulmonary Ventilators[AB] OR Respirators[AB] OR Ventilator[AB] OR Pulmonary Ventilators[AB] OR Ventilators[AB] OR Pulmonary Mechanical Ventilation[AB] OR Ventilation, Mechanical [AB] OR "Ventilators, Mechanical"[MH] OR "Ventilators, Mechanical"[AB] )) AND (Alarm, Clinical[AB] OR alarm[AB] OR alarms[AB] OR alarm fatigue[AB] OR Alarms, Clinical[AB] OR Clinical Alarm[AB] OR "Clinical Alarms"[AB] OR "Clinical Alarms"[MH])))  Filters: Publication date from 2010/09/20 to 2020/09/20 | 59 |

- **SCOPUS**

| | |
|---|---|
| Q1 | TITLE-ABS-KEY ("Ventilators, Mechanical") OR TITLE-ABS-KEY ("Pulmonary Ventilator") OR TITLE-ABS-KEY ("Ventilators, Mechanical") OR TITLE-ABS-KEY ("Respirators") OR TITLE-ABS-KEY ("Ventilator") OR TITLE-ABS-KEY ("Pulmonary Ventilators") OR TITLE-ABS-KEY("Ventilators") OR TITLE-ABS-KEY("Pulmonary Mechanical Ventilation") OR TITLE-ABS-KEY("Ventilation, Mechanical") |
| Q2 | TITLE-ABS-KEY ("Alarm, Clinical") OR TITLE-ABS-KEY ("alarm") OR TITLE-ABS-KEY (""Clinical Alarms") OR TITLE-ABS-KEY ("alarms") OR TITLE-ABS-KEY ("alarm fatigue") OR TITLE-ABS-KEY ("Alarms, Clinical") OR TITLE-ABS-KEY ("clinical alarm") |

| **SCOPUS** | RESULT |
|---|---|
| **SCOPUSE** | 27 |
| TITLE-ABS-KEY ( ( ventilators AND mechanical ) OR ( pulmonary AND ventilator ) OR ( ventilators AND mechanical ) OR ( respirators ) OR ( ventilator ) OR ( pulmonary AND ventilators ) OR ( ventilators ) OR ( pulmonary AND mechanical AND ventilation ) OR ( ventilation AND mechanical ) AND ( alarm AND clinical ) OR ( alarm ) OR ( clinical AND alarms ) OR ( alarms ) OR ( alarm AND fatigue ) OR ( alarms AND clinical ) OR ( clinical AND alarm ) ) AND PUBYEAR > 2009 AND PUBYEAR < 2024 AND ( LIMIT-TO ( SUBJAREA , "NURS" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "cp" ) OR LIMIT-TO ( DOCTYPE , "re" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) ) | |

- **EMBASE**

| | | |
|---|---|---|
| Q1 | (((((((('ventilator'/exp OR 'ventilator' OR 'mechanical ventilator'/exp OR 'mechanical ventilator' OR ventilators,) AND mechanical:ab,ti OR pulmonary) AND ventilator:ab,ti OR pulmonary) AND ventilators:ab,ti OR respirators:ab,ti OR pulmonary) AND ventilators:ab,ti OR ventilators:ab,ti OR pulmonary) AND mechanical AND ventilation:ab,ti OR ventilation,) AND mechanical:ab,ti OR ventilators,) AND mechanical:ab,ti AND [2010-2020]/py | 49256 |
| Q2 | ((((('alarm fatigue'/exp OR 'alarm fatigue' OR 'alarm monitor'/exp OR 'alarm monitor' OR 'alarm monitoring'/exp OR 'alarm monitoring' OR alarm:ab,ti OR alarm,) AND ('clinical'/exp OR clinical) AND ab,ti OR alarms:ab,ti OR alarms,) AND ('clinical'/exp OR clinical) AND ab,ti OR 'clinical'/exp OR clinical) AND alarm:ab,ti OR 'clinical'/exp OR clinical) AND alarms:ab,ti AND [2010-2020]/py | 1949 |

| EMBASE | |
|---|---|
| (((((((('ventilator'/exp OR 'ventilator' OR 'mechanical ventilator'/exp OR 'mechanical ventilator' OR ventilators,) AND mechanical:ab,ti OR pulmonary) AND ventilator:ab,ti OR pulmonary) AND ventilators:ab,ti OR respirators:ab,ti OR pulmonary) AND ventilators:ab,ti OR ventilators:ab,ti OR pulmonary) AND mechanical AND ventilation:ab,ti OR ventilation,) AND mechanical:ab,ti OR ventilators,) AND mechanical:ab,ti AND ((((('alarm fatigue'/exp OR 'alarm fatigue' OR 'alarm monitor'/exp OR 'alarm monitor' OR 'alarm monitoring'/exp OR 'alarm monitoring' OR alarm:ab,ti OR alarm,) AND ('clinical'/exp OR clinical) AND ab,ti OR alarms:ab,ti OR alarms,) AND ('clinical'/exp OR clinical) AND ab,ti OR 'clinical'/exp OR clinical) AND alarm:ab,ti OR 'clinical'/exp OR clinical) AND alarms:ab,ti AND [2010-2020]/py AND [english]/lim | 70 |

- **PROQUEST**

| | | |
|---|---|---|
| Q1 | AB,TI(Ventilators, Mechanical) OR AB,TI(Pulmonary Ventilator) OR AB,TI(Ventilators, Mechanical) OR AB,TI(Respirators) OR AB,TI(Ventilator) OR AB,TI(Pulmonary Ventilators) OR AB,TI(Ventilators) OR AB,TI(Pulmonary Mechanical Ventilation) OR AB,TI(Ventilation, Mechanical)<br>Limited by: Full text, Peer reviewed<br>Date: From December 01 2010 to December 01 2020<br>Language: English | **4,523** |
| Q2 | AB,TI(Alarm, Clinical) OR AB,TI(alarm) OR AB,TI(alarms) OR AB,TI(alarm fatigue) OR AB,TI(Alarms, Clinical) OR AB,TI(Clinical Alarm) OR AB,TI(Clinical Alarms) OR AB,TI(common alarm) OR AB,TI(important alarm) OR AB,TI(Alarms, Clinical) OR AB,TI(common reasons<br>Full text, Peer reviewed<br>Date: From December 01 2010 to December 01 2020<br>Language:English | **6,119** |

| PROQUEST | |
|---|---|
| ((AB,TI(Ventilators, Mechanical) OR AB,TI(Pulmonary Ventilator) OR AB,TI(Ventilators, Mechanical) OR AB,TI(Respirators) OR AB,TI(Ventilator) OR AB,TI(Pulmonary Ventilators) OR AB,TI(Ventilators) OR AB,TI(Pulmonary Mechanical Ventilation) OR AB,TI(Ventilation, Mechanical)) AND PEER(yes) AND la.exact("English") AND pd(20101201-20201201)) AND ((AB,TI(Alarm, Clinical) OR AB,TI(alarm) OR AB,TI(alarms) OR AB,TI(alarm fatigue) OR AB,TI(Alarms, Clinical) OR AB,TI(Clinical Alarm) OR AB,TI(Clinical Alarms) OR AB,TI(common alarm) OR AB,TI(important alarm) OR AB,TI(Alarms, Clinical) OR AB,TI(common reasons)) AND PEER(yes) AND la.exact("English") AND pd(20101201-20201201)) | **108** |