

# Noise Reduction in an Intensive Care Unit: Implementation of Quiet Time and Noise-Reduction Strategies

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## Methodology

**Keywords:** Quality Improvement, PDSA, Quiet time, Noise reduction

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# Abstract

**Background:** Excessive noise is a significant problem for patients in intensive care units (ICUs) and is associated with significant psychological effects and the potential to affect patient outcomes. The noise level in our coronary care intensive unit of a cardiac hospital was found to be approximately 80 dB, which exceeded the international recommended level of 35 dB. We sought to review the causes of this excess noise and the effects of an implementation of quiet time and a noise-reduction bundle in the ICU.

**Methods:** A quality improvement initiative was undertaken to solve the noise issue. A multi-disciplinary team was formed and a number of changes were tested. We used a model for improvement, and the changes were tested using small Plan-Do-Study-Act cycles. Two blocks of quiet time (3-4 pm and 2-4 am) were designated as quiet times during which the lights were dimmed, noise-reduction strategies in the form of a bundle were implemented, and procedures were minimized. In addition, educational material and information were disseminated to physicians, nurses, physical therapists, and other potential individuals who might be affected by the changes that were implemented. Quantitative baseline data was collected using sound meter readings three times a day. Qualitative feedback was collected through staff and patient surveys.

**Results:** During quiet hours, the noise level averaged 22 dB—a decrease from 85 dB. One-hundred patients were surveyed and asked for their feedback concerning quiet time: approximately 97% of them were satisfied with the results.

**Conclusions:** It is possible to reduce noise levels in ICUs by implementing simple and effective measures. This reduction has a significant effect on patient satisfaction, and, in addition, promotes healing.

## Contributions To The Literature

- Research has shown that significant noise levels in hospitals affect the physical and mental well-being of patients. Noise is difficult to control unless the underlying reasons are known.
- While much of the literature suggests controlling alarms will reduce noise levels, there are more contributory factors to consider.
- Our study successfully implemented a series of interventions in a number of staff behaviours and environmental causes to reduce noise levels in intensive care units and may be adopted as a successful strategy in health-care settings. These interventions involved the use of research and its application in clinical settings.

## Introduction

## Problem Description

Excess noise is a common problem experienced by patients in intensive care units (ICUs) and has negative consequences on sleep quality [1]. The disruption of sleep may contribute to the development of delirium in critical care patients and could lead to longer hospital stays and ongoing cognitive impairment, even after discharge [2, 3, 4]. We identified a similar noise issue in our coronary intensive care unit (CICU) in a cardiac facility where the noise level was found to be 80 dB, a level that is much higher than recommended by World Health Organization, which suggests noise levels in hospitals should not exceed 35 dB during the daytime and 30 dB at night [5].

In the CICU, different categories of adult patients with cardiac disease, acute myocardial infarction, advanced heart failure and post cardiac arrest are admitted. Typically, within the critical care unit a number of procedures are performed at the time of admission and during caregiving; therefore, it is always a busy unit. Many patients and relatives have complained that the noise level in the unit and have stated that it is not a comfortable area for resting. Interruptions encountered during rest time could result in delays in the healing process, as well as negative patient outcomes and lower satisfaction. Therefore, 50 patients were surveyed to assess the noise issue. We found that 98% of ICU patients reported sleep disturbances due to the high noise level in the unit. In addition, 86 staff were surveyed to obtain their input on the effect of noise on their work. Ninety-five percent agreed that the noise level was annoying and affected their regular work. This finding is in accordance with the literature, which has shown that continuous exposure to high noise levels is associated with increased stress for staff and may adversely affect physiology, motivation and general health [6–12].

## **Settings**

This effort began as a pilot project in the CICU in January 2018 under a value improvement initiative. The CICU is a 20-bed unit that serves cardiac patients and runs in three shifts: morning (6.00 to 14.00), afternoon (14.00 to 22.00) and night (22.00 to 6.00). Ventilated, critically ill patients who required high doses of inotropes and support were excluded from this intervention.

## **Available Knowledge**

Noise is unwanted sound considered unpleasant, loud or disruptive to hear [12, 13]. High noise levels are an environmental stressor and are known to have physiological and psychological effects. ICUs are noisy due to the level of care being delivered; however, this issue is often ignored. The most common cause of noise in ICUs is often attributed to staff activities and alarms from equipment and is repeatedly remarked upon by the patients as causing dissatisfaction and discomfort [14].

## **Rationale**

We received several complaints from patients as well as from visiting faculties regarding the high noise level in the unit. Therefore, a noise reduction project was initiated in the CICU to investigate the causes of the high noise levels and to address the issue.

## **Aim and Objectives**

We aimed to reduce noise in the CICU from 80 dB to 35 dB by December 2019 through the implementation of quiet time and other noise-reduction strategies. Our objectives were to recognise and analyse how to increase patient satisfaction by decreasing noise and providing quiet time, to discuss the strategies implemented to provide a quiet, healing environment, and to develop ideas for involving a multidisciplinary team to achieve quiet time.

## Methods

### Context

To build capacity for improvement, our parent organization, Hamad Medical Corporation, initiated collaboration with the Institute for Healthcare Improvement. The overall effort came under a value improvement initiative piloted in High Dependency Unit B, which aimed to improve capacity, performance and cost measures.

### Measurement Strategy

This study focused on the environmental monitoring of sound and did not involve patient/staff recruitment. It was conducted during a 12-month period, with noise measurements collected in two phases, before and after the interventions. In the pre-intervention phase, the unit's baseline noise was recorded. Data collection was performed for 2 hours during each shift, 7 days a week (morning, evening and night) and was collected from nursing stations and outside patient rooms. We found that maximum noise levels occurred during rounds at 11 am and on Thursday and Sunday mornings. Fridays and Saturdays were comparatively quiet. In addition, patient-satisfaction scores related to noise levels before and after staff education were collected.

Subsequent to baseline measurements, noise-reduction interventions were tested and implemented (e.g., staff and relatives/patient education, device alarm monitoring, and quiet time implementation).

### Interventions to Reduce Noise Levels

The CICU multi-disciplinary team identified the noise problem through patient comments. A task force was formed to address the issue through brainstorming and cause and effect analysis to identify the main reasons for CICU noise and the strategies needed to reduce it (Fig. 1). As this was a unique issue that might require unique inputs, the team developed a Supplier, Input, Process, Output, Customers diagram to further analyse the situation (Fig. 2).

The reasons underlying the high noise levels in the CICU were cardiac monitor alarms, overhead paging, staff conversations, rolling equipment such as procedure carts and housekeeping trollies moving across uncarpeted floors, metal chart holders, and medication and equipment doors, printers, and the phones of physicians and patients' family members. A Pareto analysis was performed to identify the main causes (Fig. 3) and, based on that analysis, several Plan-Do-Study-Act (PDSA) cycles were tried and tested. We used a model for improvement with rapid cycle PDSA change methodology to guide our work [15].

# Strategies to Reduce Noise in the ICU

Different strategies were attempted to reduce unwanted noise in the unit. To that end, a noise-reduction taskforce was formed whose members reminded visitors of quiet time and encouraged the use of whispering and a dedicated area for cell phone use.

A checklist was created and tested that listed tasks to be performed prior to quiet times, such as taking vital signs, blood samples, administering routine medications, dimming the lights, closing the curtains and turning off televisions.

## PDSA 1 – Patient Cohort

As the CICU has 2 stations, the critical and non-critical patients were placed in separate cohorts in different areas of the unit to allow for different strategies to be tested and implemented. Patient care was not affected by changing the stations.

## PDSA 2 – Quiet Time Implementation

There were challenges involved in devising and implementing quiet time in the ICU. Several time slots were tried over the course of a month, but were unsuccessful. Specifically, it was difficult to align a period that was free from visitation times, medication times, physician rounds, housekeeping rounds and mealtimes.

Multidisciplinary meetings were conducted with the supervisors of security and housekeeping, the catering team, physical therapists and physicians to decide timings and responsibilities. Two blocks of time (3–4 pm and 2–4 am) were designated as quiet times, during which lights were dimmed, noise-reduction strategies were implemented and procedures were minimized. Before the quiet-time period began, nurses (if appropriate) administered pain medication, pre-toilet activities and repositioning of patients to ensure a period of uninterrupted rest. At the commencement of quiet time, a one-on-one announcement was made to every patient and visitor, lights on the unit were dimmed, and visual signage was placed at the entrance to the unit stating: “Quiet Time in Progress” (Fig. 4). The staff made all possible efforts to minimize sources of noise on the unit during this period.

## PDSA 3 – Alarm Settings

A tool was developed and tested to monitor alarm sources as well as compliance in setting alarm limits on life-saving equipment. In addition, individualised alarm thresholds, volumes and the use of visual alerts were tested. Unnecessary alarms were removed from monitors.

## PDSA 4 – Multidisciplinary Approach

The housekeeping staff agreed to rescheduling the timing of bin changes to avoid disturbing patients during quiet time. In addition, care was co-ordinated to reduce unnecessary entry into patient rooms

during quiet time. Furthermore, patient handovers were conducted outside patient rooms during quiet time.

## **PDSA 5 – Yacker Tracker (Fig. 5)**

We used the audio-visual aid Yacker tracker to give alerts if the sound level in the unit was above a set level of 35 db. This audio-visual, noise-signal tool allowed the group to know when noise levels were exceeding set limits. The Yacker tracker resembles a traffic signal with red, yellow and green lights. A green smiley face signified an acceptable sound level. The yellow light signified that levels were rising, and a frowning red face indicated that the volume needed to be lowered. By providing a visual cue, the employees were able to better understand the noise level in the unit and adjust the volume of their voices. Initially, this device was not available in the unit. Therefore, before making a request for its purchase, we tested it by first borrowing a device for 1 month from a different facility. The initial results were impressive, and it helped to raise awareness regarding noise levels. Based on these results, multiple trackers were purchased for the unit. Two devices were placed at each station and the decibel level was set at 35 dBs (recommended from WHO)

## **Device Repairs**

We worked with the engineering department to change noisy wheel carts, place door stoppers in every room and pad the receiving area for pneumatic systems. These changes resulted in a significant reduction of noise in the unit.

## **Educational Interventions**

### **Staff Education**

Staff and family education played vital role in this initiative. One-to-one and small group educational sessions were conducted for all CICU staff regarding the effects of noise on patients and staff and on noise-reduction strategies. They were informed about the effects of noise on patients and staff, errors associated with noise and current interventions aimed at noise reduction in the unit. The educational sessions were arranged during regular meetings, staff meetings and journal club sessions. Comments by patients and families were shared during those sessions to create a sense of urgency. In addition, results from similar interventions from different facilities were provided to create awareness and motivation amongst the staff.

Posters and signs were placed in the unit and at the entrance of the unit to alert the health-care team and visitors about the noise levels. Posters were placed on ICU doors and hand-outs were distributed to teams and families. In addition, staff was encouraged to keep hallway conversations to a minimum, especially at night. For each shift, a noise reduction champion was assigned to monitor the effective implementation of the noise-reduction strategies and their compliance.

## **Patient and Family Education**

In addition to staff education, all admitted patients and their family members were provided education regarding quiet time during unit orientation. Families were encouraged to bring music, spiritual readings and other items to relax their family member. Hand-outs regarding quiet time were prepared, shared and explained to family members in their preferred language. We used our language bank services for patients who preferred languages other than English or Arabic.

## **Examination of the Interventions**

Apart from the implementation of quiet time, which had a direct effect on the noise levels in the units, a self-reported survey was prepared to study noise-induced effects in the unit. The questions were designed to obtain information on noise sources in the unit, attitudes towards noise and its effects, noise-induced physical and mental effects and the desirability or undesirability of various environmental conditions. Data was collected and statistically analysed to evaluate noise-induced effects. Before the initiation of the project, a taskforce team member designed operational strategies to reduce noise in health facilities, and the team members implemented all possible strategies to reduce noise in the clinical areas.

## **Outcome Measures**

The primary outcome measure was the average noise level during quiet time in the CICU.

## **Process Measures**

Compliance with how often quiet time was interrupted for non-essential reasons was calculated as a process measure.

## **Balancing Measures**

Patient, family and staff satisfaction surveys were conducted for balancing measures. In addition, comment cards were collected to obtain patient feedback.

## **Analysis**

Following the implementation of quiet-time hourly slots, data was collected to evaluate the effectiveness of the interventions.

Welch's t-test was used in this study. The Welch's t-test, also known as the unequal variance t-test, is used when the number of samples in each group and the variance of the two data sets are different. We analysed pre and post intervention noise levels in dB using this test.

Compliance to different noise reduction strategies were calculated and analysed by using run chart rules. In addition, for qualitative data, before- and after-intervention percentages of patient and staff satisfaction levels were taken using a survey.

## **Challenges and Measures to Overcome**

There were a number of challenges encountered during this initiative. One of the most important was a lack of awareness or denial regarding the noise problem. Initially, as this was a non-conventional, quality-improvement project, we faced challenges in getting the staff to believe noise was an issue that needed to be addressed. We shared patient and visitor comments to overcome this and convince the team to work on noise reduction. Another challenge was related to the nature of the work conducted in the unit, as the CICU is where emergency tasks and activities are common and continuously changing. Measuring sound and deciding upon improvement strategies was also a challenge, which was addressed through consulting the literature.

In contrast to many other distracting or unpleasant factors in a CICU, excessive noise can be reduced by the implementation of noise-reduction strategies. In our study, we were able to significantly reduce the noise level in the ICU and provide dedicated quiet time for the patients to enable them to have enough rest and sleep. Although these interventions were initially difficult to implement, once staff and patients understood the importance of the initiative, its feasibility improved. We did not attempt patient-specific interventions. Instead, environmental-based changes were tested and implemented. Patient-specific devices such as earplugs and earphones have been tested in past studies to mitigate noise, but their clinical benefit is limited [23–26].

## Results

There was a marked reduction in noise following the implementation of all strategies throughout the day. Outcomes were measured using statistical control charts, which showed significant improvement from 85 dB at the baseline level to 22 dB—a 75% reduction in noise (Fig. 6). In addition, compliance with quiet time increased from 24% at baseline to 100% (Fig. 7), as staff members became aware of the importance of quiet time and received positive feedback from patients and families. Patient satisfaction scores (as measured by the survey) increased from 10–97% in comparison with previous satisfaction data (due to their ability to get adequate sleep). Patients reported adequate rest and relaxation during quiet-time periods and agreed that it contributed to their health and wellbeing. In addition, staff satisfaction increased to 100% from a baseline value of 5%.

The mean decibel level in the CICU prior to the intervention was 72.75 dB with a variance of 81.48 dB, whilst the mean decibels post-intervention was 27.72 dB, with a variance of 47.29 dB (Table 1). At the 0.05 level of significance, we concluded that the decibel level post-intervention was significantly lower than pre-intervention levels, with a p-value of 0.00.

Table 1  
Results of noise-reduction strategies in the CICU

	<b>Decibel level pre-intervention (dB)</b>	<b>Decibel level post-intervention (dB)</b>
Mean	72.75	27.72
Variance	81.48	47.29
Observations (n)	12.00	34.00
t-value <sup>a</sup>	15.74	
p-value	0.00	
<sup>a</sup> Welch's t-test was used to analyse the pre- and post-intervention decibel changes.		

## Discussion

This quality improvement project attempted to identify noise levels in an adult ICU and assess the effectiveness of different types of educational, behavioural, and environmental interventions. Our results suggest that a bundle of noise-reduction strategies, which included engineering modifications, education of staff and relatives, changing visitation times and the implementation of quiet time were effective in reducing noise in patient rooms and the unit. We significantly reduced the sound level by 60–65 dB during quiet times, as well as during normal hours subsequent to the effective implementation of the noise-reduction strategies. Interestingly, we found an increase in noise at 4 AM (just after finishing quiet time), which we attribute to the resumption of activities such as baths, morning blood work and patient repositioning.

Sleep disturbance is a common issue in ICU settings and affects both sleep quantity and quality [16–18]. While some of the casual factors for sleep disturbance, including illness, cannot be mitigated, other environmental factors and staff/visitors' contributions to these factors can be managed [19–21].

Noise is disturbing to patients as well as to staff working in ICUs, but the staff is often the source of the noise. Major sources of noise include staff activities such as conversations between staff and visitors, equipment alarms and care activities. Some studies have suggested that staff conversations were the single-most common contributor to noise events [22].

The ability to clearly understand verbal communication, either face-to-face or through the telephone, is paramount for patient safety in hospitals. Miscommunication could potentially lead to errors such as the administration of incorrect medication. Researches has shown that similar orthographic (spelling) and/or phonological (sound) medications are more likely to be involved in medication errors, regardless of the clinician's level of experience. Hence, high background noise and poor acoustics (in particular unsuitable reverberation time and poor noise insulation) can emphasize difficulty in speech communication, and exacerbate the potential for medical mistakes.

# Strengths and Limitations

The CICU is a busy unit and we tested many changes before reaching a conclusion concerning the implementation of the noise reduction changes. In addition, the involvement of patients and their families in this initiative proved to be good idea. They felt included and displayed a high degree of satisfaction.

Although the intervention was successful in reducing noise levels in the unit, several limitations are worth noting. First, pre-intervention noise levels were not recorded for as long as the post-intervention levels. Second, 24-hour noise recording was not performed. Third, the CICU is quite busy, with a high occupancy rate and high patient turnovers; therefore, the occupancy rate was not considered as a potential confounder and the effect of the occupancy rate on noise was not calculated. Fourth, the study was not designed to capture the source of noise or the frequency of noise generation; therefore, we can only provide estimates on what contributed the most noise, and the interventions were based on those estimates. Finally, there was little quantitative baseline data. Measuring pre-intervention noise levels for longer periods of time could have provided richer and more representative data.

## Conclusions

The implementation of noise-reduction strategies, which included an audio-visual, noise-warning system and the introduction of quiet time, helped us to achieve a sustained reduction in average noise levels in our ICU. It also helped us to achieve higher levels of staff and patient satisfaction. This was likely accomplished by working on modifiable causes, such as staff conversations and cultural factors associated with excessive noise. Based on our results, we suggest that noise-reduction strategies, in addition to audio-visual, noise-warning systems, may be helpful in ICUs for noise reduction.

## Abbreviation List

Coronary Intensive Care Unit (CICU)

Intensive Care Unit (ICU)

Plan-Do-Study-Act (PDSA)

## Declarations

### Ethics approval and consent to participate

An internal review board review was not sought as all of the changes being tested were evidence based and are widely accepted internationally.

### Consent for publication

Not Applicable

## **Availability of data and materials**

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

## **Competing interests**

The authors declare that they have no competing interests.

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## **Author contributions**

PG served as Improvement advisor and prepared initial draft of this manuscript. MS led the work and has equal contribution. AA, SJ, II, JG contributed by testing and implementing change ideas and data collection. MAZ supervised whole process and supported in inventory. IMD supervised the sustainability of the process. DJCDJ contributed to the analysis and interpretation of the data. MEH played key role in educating physicians and providing leadership support.

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## **Data Sharing**

None

## **Patient consent**

Patient consent was not deemed necessary because we improved by implementing standardized process, thus, it was not necessary to obtain patient consent.

## **Ethical approval**

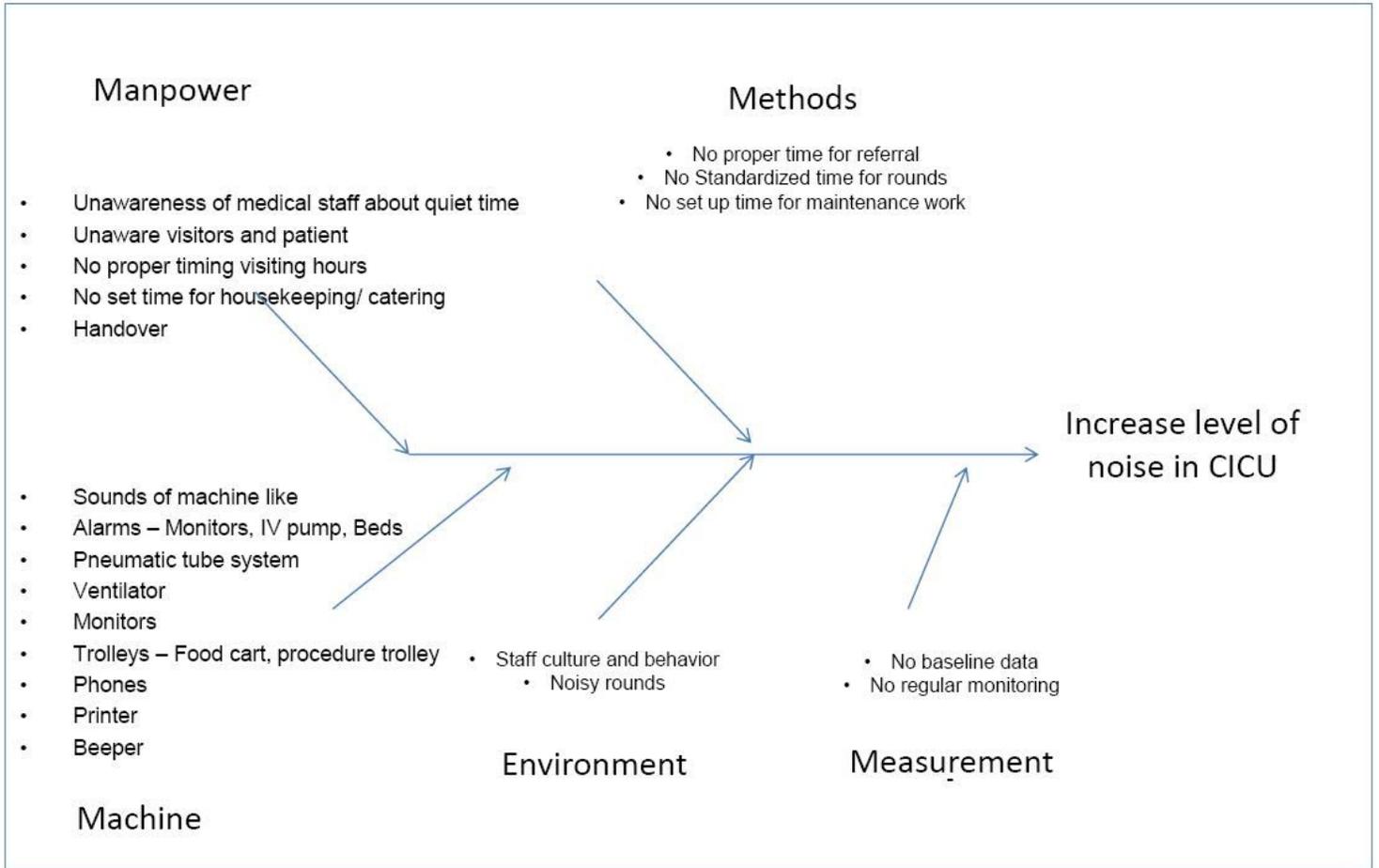
Ethical approval was not deemed necessary because we implemented noise reduction strategies based on evidence based practices.

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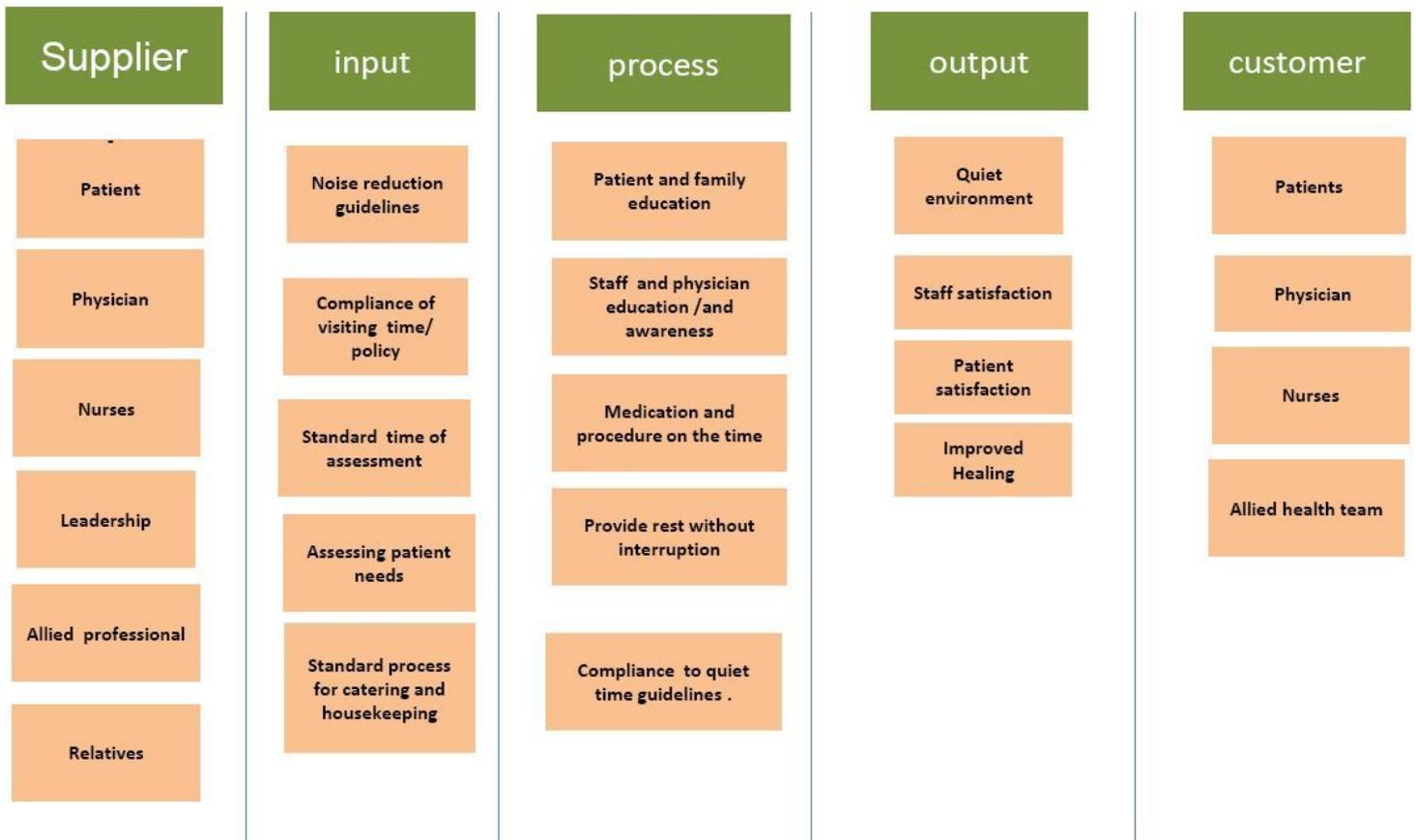
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## Figures



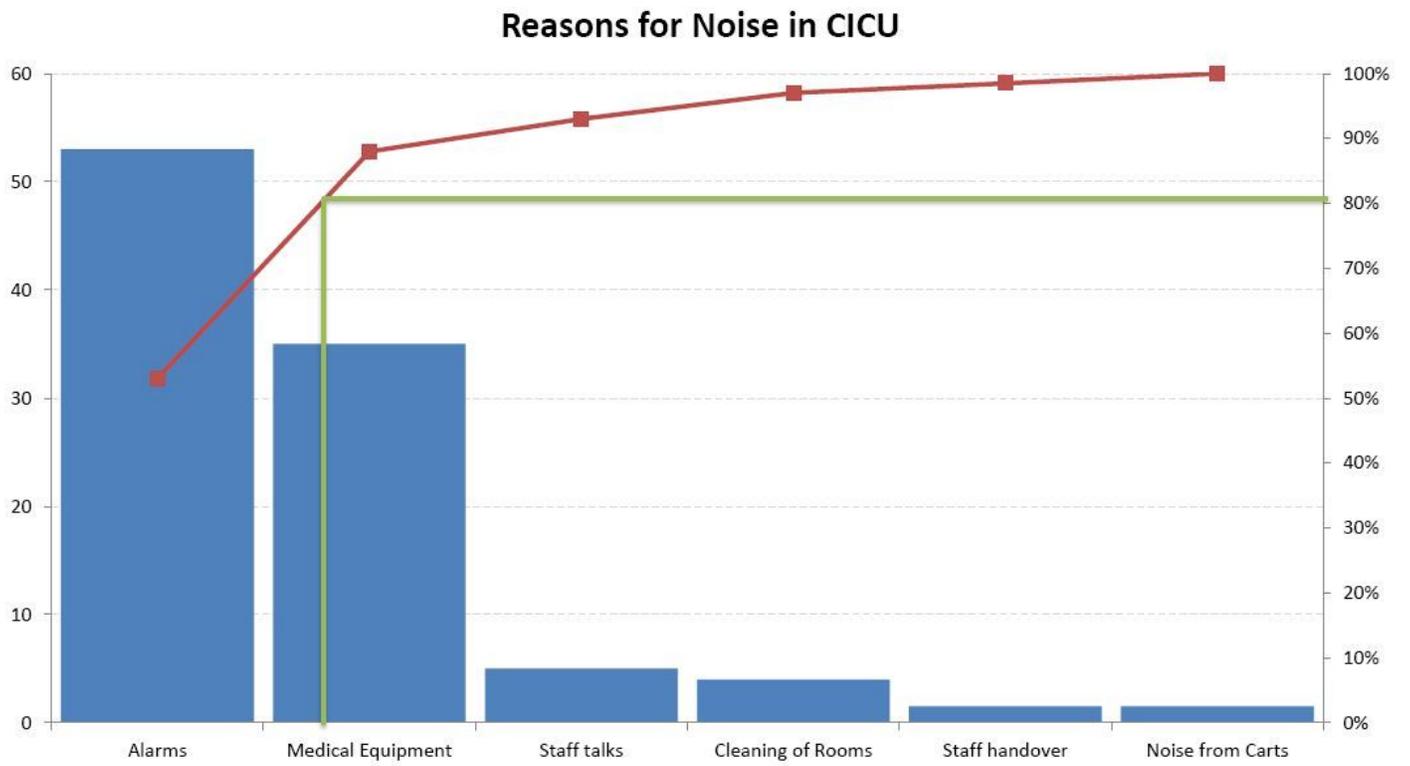
**Figure 1**

Cause and effect diagram (fish bone)



**Figure 2**

SIPOC DIAGRAM – Providing Quiet Environment in CICU. Supplier, Input, Process, Output, Customers analysis



**Figure 3**

Pareto diagram



# Coronary Intensive Care Unit



وقت هدوء للمريض  
**QUIET TIME  
IN PROGRESS**

برجاء عدم الازعاج  
**DO NOT DISTURB**

Patient satisfaction is our priority.

Figure 4

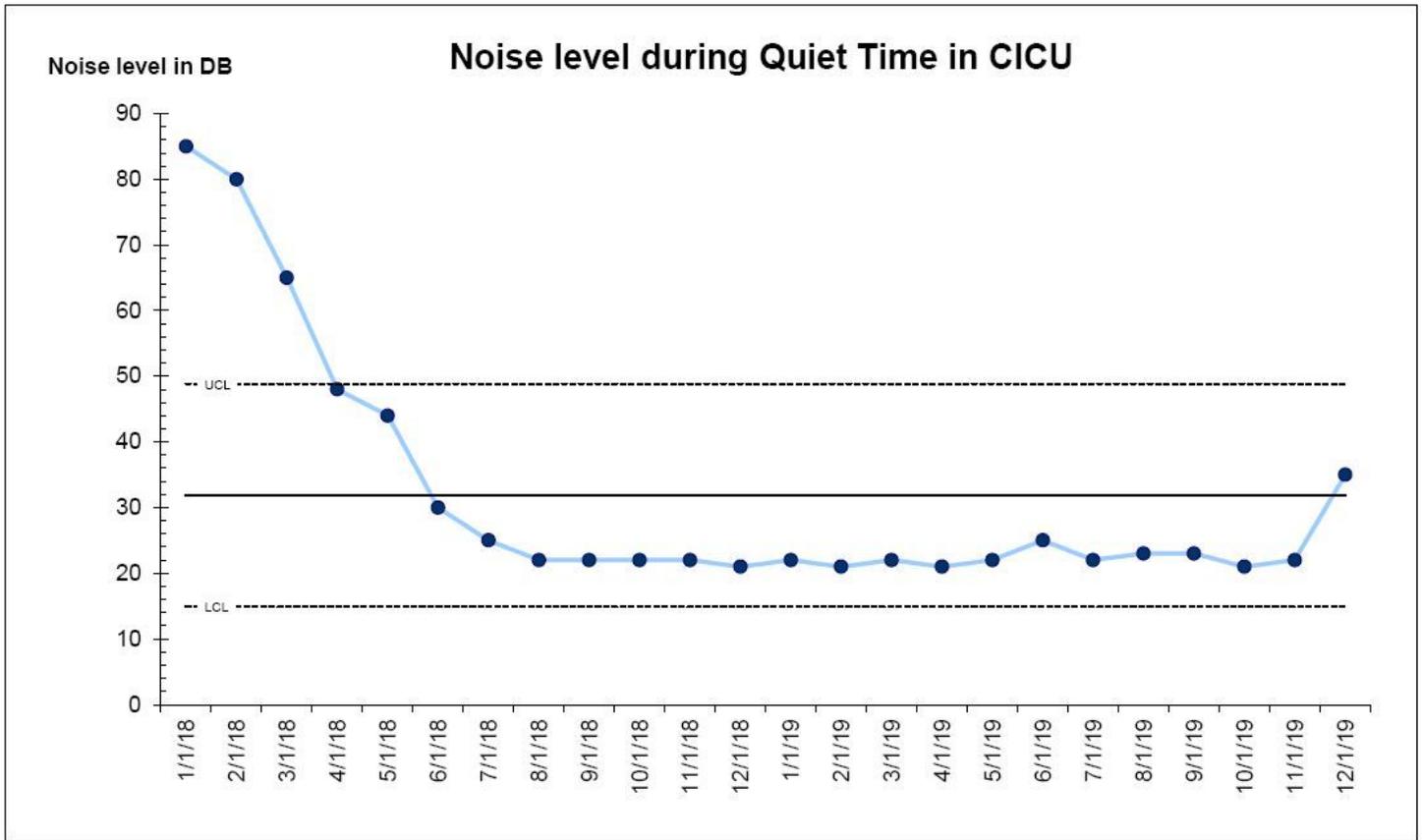
Poster – Quiet Time in Progress



This visual noise signal tool lets the group know when noise levels are getting too high. It resembles a traffic signal with red, yellow, and green lights. The green smiley face lets everyone know they're keeping it at a pleasant level. The yellow lets them know that levels are rising and the red frowny face reminds them to lower the volume. By giving everyone a visual cue, employees can take responsibility and correct the volume of their voice.

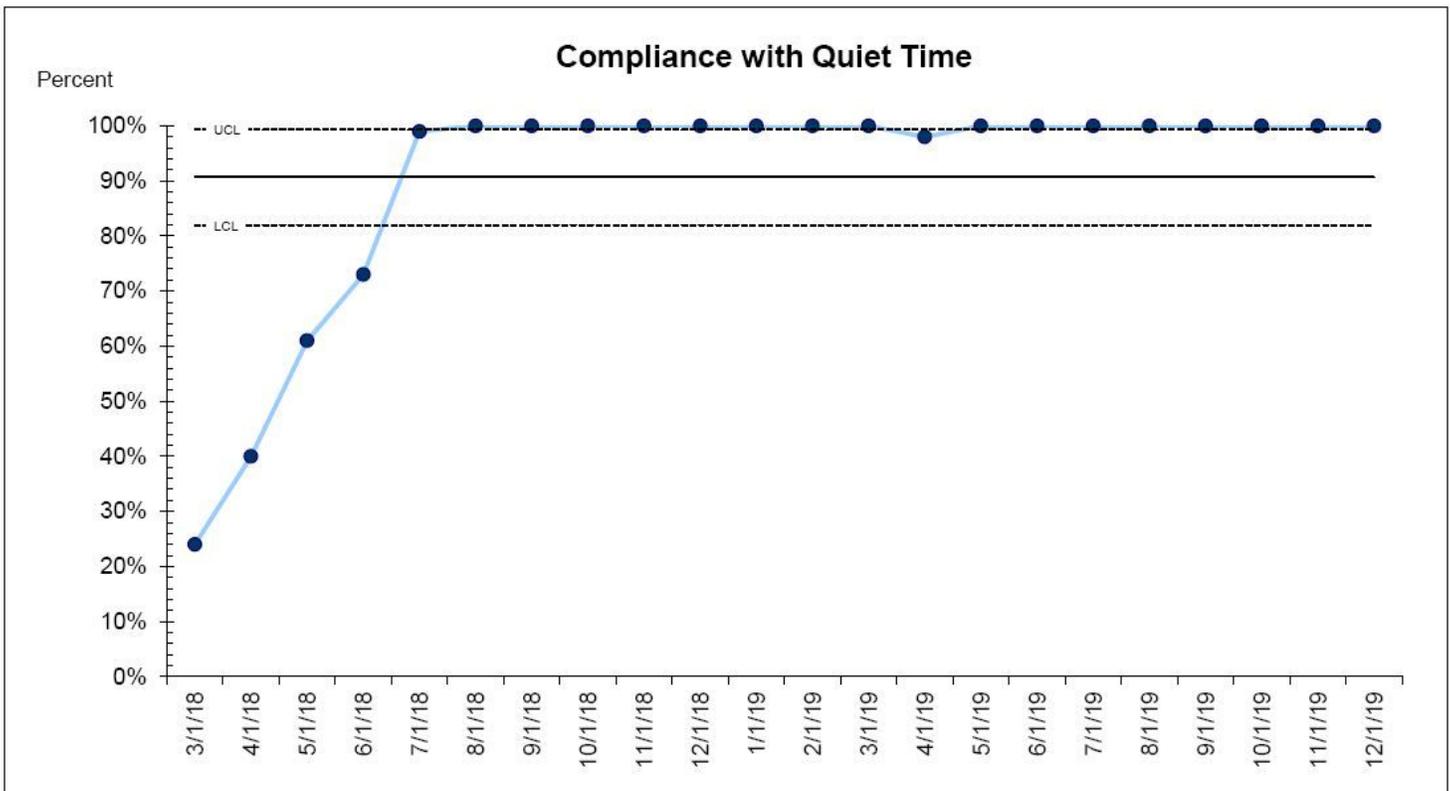
**Figure 5**

Yacker tracker – Audio-visual device



**Figure 6**

Noise level during quiet time in the CICU



## Figure 7

Compliance with quiet-time implementation

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SQUIRE2.0Checklist.docx](#)