Identifying Noise Sources & Alarm Hazards in ICUs – Occurrences. Tools to Minimize

Identificación de fuentes de ruido y riesgos de alarma en las UCI: ocurrencias; herramientas para minimizarlos

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ABSTRACT

ICU of a hospital is considered to be one of the most stressful and psychologically taxing working places because of the congregation of critically ill and severely injured patients. Patients with any life-threatening illnesses are admitted to the intensive care unit. The objective of ICUs is to assist such patients duly recover by providing them advanced treatment with the skillful application of advanced techniques. ICU is also a place where sophisticated equipment and machinery necessary to supervise and care for a seriously ill patient are strung together to meet the treatment needs of patients without the possibility of neglecting them. Part of the ICU architecture is medical device alarms. Clinical devices and other appliances sound hundreds of alarms per patient per day, creating a dissonance that can overwhelm, distract, and desensitize health care workers as well as patients. The hazards related to excessive noise and clinical alarms were conceived as a project when it was observed that the stress level of patients and care givers increased due to the noise coming out of these alarm systems. A study undertaken in one of the multispeciality Hospitals in Bhubaneswar to find out the possible sources of stress revealed that noise from alarms and other sources were proving to be a source of a hindrance for effective communication and contributing to patients’ stress. The results of our study indicate that behavioral modification alone is not adequate to control excessive noise. There is a need for further research involving the supportive involvement by clinicians, nurses, and paramedic and support staffs, along with effective medical device alarm management, and continuous process improvement methods and training.

Keywords: Psychological Factors; Intensive Care Unit; Stressors; Health Care Organization; Alarm Hazards; Medical Devices.

RESUMEN

La UCI de un hospital se considera uno de los lugares de trabajo más estresantes y psicológicamente agotadores debido a la congregación de pacientes en estado crítico y gravemente heridos. Los pacientes con enfermedades potencialmente mortales ingresan en la unidad de cuidados intensivos. El objetivo de las UCI es ayudar a estos pacientes a recuperarse debidamente proporcionándoles un tratamiento avanzado con la hábil aplicación de técnicas avanzadas. La UCI es también un lugar donde se reúnen los sofisticados equipos y maquinaria necesarios para supervisar y atender a un paciente gravemente enfermo, con el fin de satisfacer las necesidades de tratamiento de los pacientes sin posibilidad de descuidarlos. Parte de la arquitectura de la UCI son las alarmas de los dispositivos médicos. Los dispositivos clínicos y otros aparatos hacen sonar cientos de alarmas por paciente y día, creando una disonancia que puede abrumar, distraer e insensibilizar tanto a los trabajadores sanitarios como a los pacientes. Los peligros relacionados con el ruido excesivo y las alarmas clínicas se concibieron como proyecto cuando se observó que el nivel de estrés de pacientes y cuidadores aumentaba debido al ruido que emitían estos sistemas de alarma. Un estudio realizado en uno de
Los hospitales multiespecialidad de Bhubaneswar para averiguar las posibles fuentes de estrés reveló que el ruido de las alarmas y otras fuentes obstaculizaba la comunicación eficaz y contribuía al estrés de los pacientes. Los resultados de nuestro estudio indican que la modificación del comportamiento por sí sola no es adecuada para controlar el ruido excesivo. Es necesario seguir investigando con la participación de médicos, enfermeras y personal paramédico y de apoyo, junto con una gestión eficaz de las alarmas de los dispositivos médicos y métodos y formación para la mejora continua de los procesos.

**Palabras clave:** Factores Psicológicos; Unidad de Cuidados Intensivos; Factores de Estrés; Organización Sanitaria; Alarma de Peligros; Dispositivos Médicos.

**INTRODUCCIÓN**

El campo de la sanidad es inherentemente estresante debido a la críticidad de los casos y el alto riesgo implica; donde los pacientes’ vidas están en el primer plano y la muerte siempre es una posibilidad.\(^{(1)}\) Mientras que para los pacientes y sus familias, la hospitalización impuesta por una enfermedad grave puede ser vista como una crisis.\(^{(2)}\)

Los incertidumbres del entorno del cuidado intensivo debido a la congregación de pacientes graves representan un desafío que es agotador y confrontante en la misma medida. Para los pacientes, el cuidado intensivo es un asilo de esperanza y un lugar de preocupación, ya que involucra una serie de múltiples estímulos físicos, psicológicos y ambientales.\(^{(3)}\)

El cuidado intensivo es un caso de atención médica, que proporciona cuidado especializado a pacientes críticos con problemas médicos complejos para sostener la vida fisiológica. Es una parte de la institución que está dedicada a los pacientes con enfermedades críticas que requieren cuidado intensivo. Incluye una gama amplia de intervenciones, observación y monitoreo por parte de sofisticados equipos médicos y tratamiento por parte de un equipo de médicos especializados.\(^{(4)}\)

Un vistazo ilícito alrededor de un hospital clínico con alarmas en sistemas de cuidados médicos mostraría cómo se expande el uso de dispositivos médicos basados en alarmas, y sobre la dependencia del sistema de salud en los sistemas de alarma en los sistemas de cuidados médicos para mejorar la eficiencia.

El uso de alarmas de cuidados intensivos ha presentado un salto considerable en el cuidado intensivo, donde típicamente un paciente tiene hasta una docena de dispositivos médicos con alarmas atados a él. El ambiente y el ambiente de cuidado crítico unido con el deterioro de la paciente tienen un ambiente de cuidado crítico lleno de estímulos extraños y familiares sonidos, iluminación brillante continua, ruido procedente de los equipos de respiración, monitores de signos vitales y otros equipos de equipo.\(^{(5)}\)

La atmósfera en un cuidado intensivo es todo menos tranquila y calmada que es necesario para la recuperación de un paciente mayor recupere de una enfermedad crítica.\(^{(6)}\)

El riesgo de alarmas clínicas ha continuado largo lo suficiente para ser reconocido como una cuestión de seguridad del paciente. Los desastres de alertas de fatiga de alertas han sido ampliamente investigados y la ocurrencia de alarmas adversas relacionadas con los incidentes fue lo suficientemente común para ser objeto de reconocimiento. La alerta de fatiga ha sido reconocida por la ECRI Institute’s 2020 report for Top 10 Health Technology Hazards.\(^{(7)}\)

Mientras que en una huella de alarmas de cuidados intensivos han convertido en una amenaza de seguridad de los pacientes con fatiga de alarma del sistema de alertas médicos con posibilidades mortalmente consecuencias, niveles de ruido en el cuidado intensivo han emergido como un asunto de estres y una causa para preocuparse. El nivel de decibeles de ruido en el cuidado intensivo han sido encontrados de superar el nivel de decibeles de ruido de los hospitales multiespecialidad de Bhubaneswar para averiguar las posibles fuentes de estrés reveló que el ruido de las alarmas y otras fuentes obstaculizaba la comunicación eficaz y contribuía al estrés de los pacientes. Los resultados de nuestro estudio indican que la modificación del comportamiento por sí sola no es adecuada para controlar el ruido excesivo. Es necesario seguir investigando con la participación de médicos, enfermeras y personal paramédico y de apoyo, junto con una gestión eficaz de las alarmas de los dispositivos médicos y métodos y formación para la mejora continua de los procesos.

**Review of literature**

El estudio destaca la deficiencia de atención y la falta de observación por parte de los proveedores de atención sanitaria para detectar cambios en el estado del paciente como la razón de muchos accidentes de cuidado intensivo.\(^{(8)}\) Para mejorar la seguridad del paciente en el cuidado intensivo, los sistemas de monitoreo se diseñaron para medir variables del paciente y, en consecuencia, los sistemas de alarmas...
were added to draw the attention of caregivers if the patient variables were below or beyond acceptable levels.

In another study it is pointed out that many problems have been reported in the critical care areas of the hospital, especially the ICU and the operating rooms regarding auditory warnings. They note that there is a suffusion of medical device systems alarms in the ICU and the constant and loud alarm tones have been deemed vexing by the care giving staff.

The problem is further accentuated by the lack of standard agreement between manufacturers on the auditory warnings used for medical equipment. This usually translates into the same piece of medical device producing different alarms because they have different manufacturers. Adding to the confusion is the incongruity of alarm systems in terms of urgency mapping, i.e. the acoustic urgency of the alarms was not always linked to the clinical urgency of the situation. This leads to increased numbers of false alarm rates and low response levels because of a lack of trust or perceived unreliability of the alarms system by the user.

The problem of high false alarms has been cited by Carrol who contends that the presence of high numbers of alarms and the rate of false alarms makes it tough for the caregivers to locate the alarm source amidst a bevy of high-pitched systems like, infusion pumps, ventilators, and also distinguish the important ones that require an immediate response.

To deal with typical alarm-related problems and alarmfatigue, nurses have been known to silence alarms or unsafely modify alarm settings to counter alarm overload. Modifying alarm settings or turning them off and then forgetting to activate the electronic monitor to signal the next crisis led to the death of a patient. 

ICU alarms should never be turned off. Instead, significant efforts should be made to improve alarm safety and reduce alarm nuisance by reviewing alarm-based technologies and processes, the hospital's clinical alarm protocols and the response of clinical users.

Noise, simply put, is defined as unwanted sounds having both psychological and physiological implications for people. explains that people's response to noise is determined by its decibel levels or loudness, what the noise represents and personal sensitivity levels; with loudness being a function of sound intensity and frequency. There it is further described that frequency as pitch, expressed in cycles per second, and that sound intensity is measured in decibels [dB] on an exponential scale. The World Health Organization (WHO) recommends that the average background noise in hospitals wards should not exceed 30 A weighted decibels (dB[A]), with nighttime limits not exceeding 40 dB(A). 35 decibels of noise and less is considered appropriate for sleeping and noise levels in the ICU should not exceed fifty decibels (50 dB(A)).

One of the studies also have determined that there is a profusion of environmental noise in the ICU from alarms, movement of people and objects, people talking or laughing, coughing patients, telephones, computer printers, and mechanical equipment that adds to the noisiness of the space with potential interference in speech and sleep disturbances because of the increased stimuli from unwanted sounds.

Noise is also referred as acting as a hindrance to optimal care by acting as a barrier to verbal communication among caregivers. They also reported that environmental noise could also be a stress factor for nurses, resulting in deficient attention and hampered efficiency.

The impact of the application of automated human voice delivery to warning devices has also been explained in earlier studies where it has been found that the patients perceived the conventional non-verbal signal as threatening.

Sleep disturbance is a regular problem for ICU patients as the noise levels range from 50 to 75 dBA, reaching a peak level of 103 dBA at night.

The effect of noise on the quality of sleep of ICU patients was studied and it was confirmed the adverse consequences of noise on the sleep quality in ICU patients and advocating strengthening the usefulness of noise-mitigation strategies.

It has also been found out that the negative influence of noise on patients' sleep in ICU includes cardiovascular stimulation, hearing loss, increased gastric secretion, pituitary and adrenal gland stimulation, and suppression of the immune response to infection.

**METHODS**

The ICU in-patients of a 350-bed multi-speciality Corporate Hospital at Bhubaneswar were the subjects of the study. Only adult patients above the age of 18 admitted to ICU were included as subjects for the study. Informed consent was obtained in all cases.

The study includes both qualitative and quantitative methods because the approach provides a comprehensive understanding and ensures the outcomes that were apparent in the study involving intense human emotions revealed through interaction is accounted for and not limited to numerical data and statistics.

Additionally, the mixed model approach helped provide an enhanced understanding of data by drawing meaningful and defensible inferences on the meanings, intentions, context, and consequences of the collected data.
The questionnaire for the patients was based on studies conducted for Hospital stress items by Volicer and further studies conducted in the ICU settings by Ballard. The questionnaire was in bilingual English and Odia. The responses from the study subjects on the administered questionnaires were analyzed on a 5-point scale. This formed the basis for quantitative analysis. The respondent's versions, expressions, gestures, and postures were duly recorded for qualitative analysis.

The first stage (Stage -I) of the study was a pilot study of two weeks, where thirty minutes of intense personal interactions were held to collect an in-depth understanding of different aspects of patients’ experiences in the ICUs and their perceptions of the items of the questionnaires. This helped in the development of the study instrument which was an adaptation of the English VolicerTest.

In Stage II, it was item analyzed to retain the required items in the questionnaire.

Stage III was the pre-intervention data collection where the revised adopted study instruments were administered.

The revised adopted study instruments comprising 50 items were administered to 125 patients to identify and understand the source and nature of stress faced by them in the ICU.

Stage IV involved the implementation of the devised plan of action to manage and counter the stress experienced by the ICU patients who formed the subjects of the study.

Stage - V describes the post-intervention data collected to understand the efficacy of the measures implemented.

RESULT AND DISCUSSION

In the study undertaken on the patients of the ICUs, who volunteered as subjects, to identify the possible sources of stress in stage III, it was revealed that noise from alarms and other sources were proving to be a source of a hindrance to effective communication and contributing to patients' stress.

Based on these findings as discussed in the above paragraphs, an action plan was developed and implemented, in accordance with the priorities, hospital's mission & vision, hospital standardized policies, financial concurrence, human commitment and with the approval of the Head of the Unit.

Stage III: Response of ICU patients to the questionnaire on item No. 4:

The psychological item listed number 4 in the questionnaire on which the stress level of the patients was assessed was found to be having a disturbing effect on the respondents.

<table>
<thead>
<tr>
<th>Item No (N=50)</th>
<th>Contents</th>
<th>Mean (Max =5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Sleeping in a noisy room with continuous voices from monitors and staff</td>
<td>3,90</td>
</tr>
</tbody>
</table>

Table 1 represents the response of patients on the item number one. Sleeping in a noisy room with continuous voices from monitors and staff was responded as stressful by 69,60 % of patients out of which 36,80 % of patients found it as slightly stressful. This Item is a validated source of stress in the hospital ICUs.

Interaction with the patients revealed that during third to seventh day of their hospitalization in ICU, they found this item to be highly stressful. Such a stressful experience can also lead to ICU psychosis which is said to occur on third day of illness and admission to the ICU.

The hospital care comes with the cost of privacy and more so when a patient is admitted in an ICU. Patient has to share the space with other patients and the continuing noise from the ICU apparatus, the nurses might also be a point of stress.

The qualitative experiences from the interactions held with the ICU patients revealed a lot of facets.

"The beeping of the monitors is disrupting my sleep more than the sounds of human voices. I can't sleep and it is irritating," said a visibly disturbed patient.

An ICU is steaming with plenty of highly sophisticated medical equipment which has a sound of its own along with its beeps and alarms so there is constant noise emanating from these equipments. The nursing staffs in charge of ICUs can also contribute to the noise levels whenever they are discussing among themselves or attending to other patients. All this chatter or beeping noise might be a source of disturbance to the patients.

"I have a weak heart and sounds frighten me in current physical and psychological conditions. The machines in these rooms keep making strange noises. They keep beeping and buzzing and it is throughout the day," said a patient complaining about the noise levels in the room.

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Another patient said, "I find it hard to get sleep here and whenever I do manage some sleep the telephone in the room buzzes or the nurses are chatting. The beeps from machines go off intermittently interrupting my sleep," said a tired-looking patient.

Another patient said, "I find hard to get sleep here and whenever I do manage some sleep the telephone in the room buzzes or the nurses are chatting." He isn't alone in his frustration. Another patient said, "Noise levels are disturbing and upsetting, most of the noise generated by rowdy staff and large groups of visitors that had no care or concern about anyone else in the hospital. I hope the hospital starts disciplining their staff and enforcing quiet zones on ICU floors."

"The beeps from machines go off intermittently interrupting my sleep," said a tired-looking patient.

Stage IV: Action Plan Implementation

The information that emerged from stage III became the subject of intense debate and discussion. The brainstorming sessions took into account patients as stakeholder, management, consultants and patients and their attendants who had been in the hospital for a considerable length of time.

These sessions threw up some very interesting insights which formed the core of the action plan that were devised to mitigate the effects of stress and to reduce the incidents of stress in the ICUs. The action plan implemented also focused on strengthening the activities that the stakeholders found to be highly or slightly reassuring or important for them, along with devising countervailing measures to compensate the effects of highly or slightly stress inducing items. The implementation of action plan is spread out over a period of two years and the measures that prove to be effective shall be adopted and sustained into the future.

Stage IV: Action Plan Implementation

To offset the stress that was due to the noisy rooms, and to avert the harmful effect of stress arising out of undesirable levels of noise a project named “SHHH Project” (Silence Hospital Helps Healing Project) was undertaken to check and manage the decibel levels on the hospital premises and to create noise free zone at patient care areas. Along with this, the staffs were educated on observing silence inside ICUs. Visitors were also made to participate in the SHHH initiative as a stakeholder and were asked to support and observe silence while visiting their patients inside ICUs. Education brochures were displayed across the hospital to give a visual illustrate about this program. Signage like “maintain silence please”, “please switch off your mobiles”, “your speaking hurts” etc were displayed at patient waiting areas and other important areas where silence is a necessity as a message for the patients to extend their co-operation in maintaining a silence zone.

Figure 1. ‘SHHH Project”: Silence Hospital Project taken up to create Silent environment for patients and to facilitate faster healing; messages displayed across the hospital

The figure 1 shows the message displayed at various strategic location in the hospital as a reminder for staffs to follow creating a silent environment for patients. The crux of the program included educating hospital staff about the harmful effect of noise and requesting them to maintain the minimum levels of voice while communicating with each other. The staffs were asked to keep their mobile in silent mode while at work.
To reduce the stress due to non-availability of medium of entertainment like TV, radio and also the newspapers, management called for a meeting of ICU Consultants and other staffs working in ICUs. It was concluded from the discussion that this result is derived from the responses of only those patients, who are conscious, oriented and can read because most of the patients in ICUs are critical or on ventilator or disoriented. Hence, a TV would only add to the problem of noise pollution or addition instead of providing entertainment or distraction. A decision was taken in favor of newspaper to make them available to patients who are conscious and are interested in reading paper on their own.

The hospital has been operational for the last 10 years and most of the machineries and equipments like trolleys, wheelchairs, stretchers etc have undergone wear and tear. These emanate noises that could have been the reason for bringing about stress in patients. The waiting area is adjoining the ICUs where attendants wait on information for the patients. It has been observed that an increase in the no. of visitors in the waiting area makes the place crowded and noises which might have been the source of stress for the patients in ICU.

The ongoing maintenance and repair work in the ICUs and the areas nearby might also bring about a feeling to the patients in ICUs that the ICUs are noisy.

For reducing the noise level of the Alarm systems; Health care workers/ nursing staffs were educated on the equipment management to keep them alert. They were further educated and trained on how to reduce the noise level of these equipments.

Noises emanating from the squeaky wheels, trolleys equipments, machines, wheels and doors which could be repaired were promptly assigned to the maintenance department and those which were beyond repair were replaced with the new acquisitions.

**Chart 2.** Alarms present in the system and are sufficiently audible with respect to distances and competing noise within the unit (Nursing Station)

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**Stage V: response of ICU patients post intervention for item No.4**

The post intervention data collection period is necessitated to assess the impact of action plan implemented, by analyzing the change in the perceptions of the stake holders, post the implementation of the action plan. This exercise enabled to develop an understanding of the efficacy of the plan and to come out with suggestions
or recommendations that can make the ICU Patient’s comfortable with their hospital stay. The impact of the interventions was assessed by administering a paired t-test. The result is as follows (Table 2).

Table 2. Depicts the mean and percentage of the responses of patients for the parameter - Sleeping in a noisy room with continuous voices from monitors and staff in Pre and post intervention stages

<table>
<thead>
<tr>
<th>Item No. (N=50)</th>
<th>Contents</th>
<th>Mean (Max =5)</th>
<th>% of patient’s response as stressful</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>4</td>
<td>Sleeping in a noisy room with continuous voices from monitors and staff</td>
<td>3,90</td>
<td>3,41</td>
<td>36,80</td>
</tr>
</tbody>
</table>

Source: Own elaboration.

The analysis of the data for the post intervention period focused on understanding the efficacy of the action plan implemented. On analyzing the responses to the administered questionnaires in this period of study, it was revealed that the action plan implemented have worked towards alleviating effect of the item no. 4 that had stressful effect for the patient in the pre intervention period.

The comparative data for the pre and post intervention period highlight a positive net effect that can be very much substantiated by the P-values. This conveys the stress has been significantly countered by the measures put in place in the action plan implementation stage. The action plan implemented had a positive impact as evident by respondent’s view in the post intervention period.

CONCLUSION

In the current scenario where, increasing emphasis is being laid on comprehensive care and holistic treatment for the patients that include in its ambit the wellbeing of the patient, attendants and the care givers, this study is a case for deep engagements and interactions for a comprehensive understanding of the patient’s experiences in ICUs. For the period this study was alive, it covered vast activities and, in the process, identified the existing gaps in the ICU noise management, devised interventional strategies, action plan was implemented that yielded positive results in the perception of ICU experiences of patients regarding the parameter: “Sleeping in a noisy room with continuous voices from monitors and staff”. It highlighted the importance of considering qualitative approach towards understanding the different experiences, perceptions of patients. Since humans are in the Centre of all health care activities, more time devoted to understanding the many facets of human well-being would contribute a great deal in reducing the stress that envelops the Patients and other stakeholders. This study focuses on clearly identifiable and discernible dimensions which is changed and shown to make a change.

The project stands out for its comprehensiveness and differentiates itself because of the detailed work that was undertaken where even the minute parts were accounted for. Noise is a source of stress but the sources of it at ICU, contribution of alarms and alarm induced distraction and stresses have not been given required importance. This study went in depth, identified the alarm issues, and deployed measures that limited the alarms from turning alarming. If proof of the pudding is in the eating, then the positive results speak for themselves. The uniqueness and the extent of success of the measures implemented make this research a starting point for other researches to build on in their effort to improve the ICU experiences and mitigate the attendant ICU stressors.

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Writing - Review & Editing: Swetapadma Dash.