SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

To evaluate the typical acoustic quality of NICU rooms as well as individual incubators by monitoring noise levels and analyzing them with artificial neural networks.

Characterizing the acoustic environment in a Neonatal Intensive Care Unit

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Key Concepts/Context

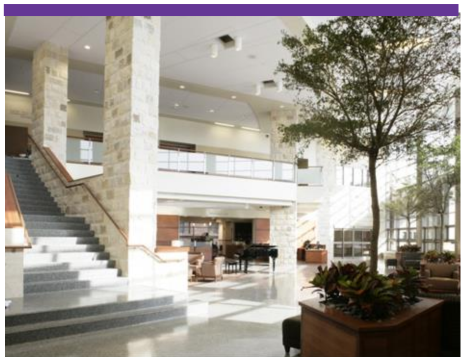
Previous research shows that the acoustic environment of neonatal intensive care units (NICUs) plays a significant role in the development of neonates; however, there is a lack of research exploring the different types and impacts of specific noise sources. The results of this study affirm that equipment alarms profoundly influence NICU noise levels, while staff conversations, telephone use, and equipment movement also contribute. One effective design solution could be replacing acoustic alarms with visual signals.

Methods

This study was performed in the NICU of a university hospital. The NICU housed 13 incubators which were equipped with monitoring systems for protecting the neonates. These included five Dräger Caleo incubators, five Ohmeda Medical Giraffe Omnibed incubators, one Ohmeda Medical Ohio Care Plus 3000 incubator, and two Dräger Babytherm thermal cots. All incubators were equipped with Siemens SC 7000/9000 XL top-end monitors. There was also a central monitoring system which provided general control of all incubators.

Noise measurements were gathered using a B&K 2270 Sound Level Meter (Class 1, measuring range 20-140 dB, 3 Hz-20kHz) and a B&K Type 4231 calibration system (Class 1, calibration range 94-114 dB, 1000 Hz). Sound-level meters were installed in all incubators individually as well as the general area of the NICU room. Microphones were mounted near the head of neonates, and the general area of the room was measured from a microphone that was placed in the center of the room near two incubators (2 meters from the nearest wall, at a height of 1.3 meters).

Data were gathered every one second over a period of 24 hours. NICU room data were gathered on a different day from incubator data in order to minimize interference with staff operations. Parameters gathered each second included: 1) A-weighted equivalent continuous sound levels (L_{Aeq}), 2) 1/3 octave bands from 12.5



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Hz to 20 kHz in the spectra, 3) L_{AF} percentiles (maximum and minimum), and 4) impulse-weighted level (L_{AIeq}). Data were processed with the software Evaluator Type 7820 and Microsoft Excel.

Finally, an artificial neural network (ANN) of the multilayer perceptron (MLP) type was trained and used to classify noise sources.

Findings

Several different noise sources were detected in the NICU room and the incubators. The primary generators of noise included: 1) medical staff shifts, telephones and mobile phones, neonatal crying, furniture and other objects being dragged, and alarms from medical equipment.

The quietest nighttime period in the NICU room was measured at 48.1 dBA, while the A-weighted equivalent continuous sound levels (L_{Aeq}) ranged from 59.8 to 69.1 dBA. An alarm indicating temperature generated the greatest L_{Aeq} value. Overall, NICU staff contributed the most to the overall L_{AFMAX} measurement; while their conversations contributed little to the overall noise level, they were present for the longest time in the room, existing for 67% of the data collection period.

For measurements gathered from inside the incubators, the sound of furniture being dragged exhibited the highest L_{AEQ} and L_{AFMAX} values. This shows that the movement of tool trolleys by staff and chairs by visitors significantly impacted the acoustic environment within the incubators. In general, the incubators were not necessarily insulated from the other noise sources detected in the NICU room, meaning the temperature alarm was also presenting significantly high sound levels.

Considering the data from both the NICU room and the individual incubators, the values for different noises exceed the acceptable thresholds set by previous research and guidelines, which recommend that overall background noise within an NICU remain below a 55 dBA threshold and should never exceed 70 dBA.

Limitations

The authors note that processing sonic data using artificial neural networks helped classify some types of noise, but they were also confronted with simultaneous occurrences of artificial and natural noises and a lack of sound spectrum uniformity, which hindered the clear interpretation of some results. This study took place within a relatively short time period (24 hours) in a single location; its results may not be reflective of daily operations within this NICU or NICUs elsewhere.

Design Implications

In order to reduce noise levels, visual cues could be considered as replacements for audible alarms on certain pieces of NICU equipment, where possible. Additionally, tool trolleys and chairs within the NICU could be equipped with wheels that roll quietly or padded feet to reduce dragging noises. Separate staff discussion areas could reduce noise from conversations.

And Also...

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