Journal of Neonatal Nursing (2016) 22, 159—162

www.elsevier.com/jneo

ORIGINAL ARTICLE

Acoustic environment profile of the neonatal intensive care unit: High ambient noise and limited language exposure☆

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Available online 20 March 2016

KEYWORDS
Neonatal intensive care unit;
Infant newborn;
Infant premature;
Noise/adverse effects/prevention and control;
Language development;
Language delay;
Neonatal development

Abstract Infants in single-patient neonatal intensive care unit (NICU) rooms may experience developmental language delay because of reduced language exposure. We evaluated the acoustic profile of a level IV NICU using Language Environment Analysis (LENA) for 40 singleton infants. Mean and peak sound levels were consistently above 45 dB the recommended standard. NICU patients experienced substantial variability in language exposure (range: 10—2040 words per hour). Neither noise levels nor word counts were associated with illness severity, gestational age, or postmenstrual age at the time of recording. Noise levels were not driven by spoken language, which suggests that interventions to optimize the NICU acoustic environment should focus on minimizing facility noise, and that interventions designed to enrich neonatal language exposure may not significantly raise ambient noise levels.

Abbreviations: Neonatal Intensive Care Unit, NICU; NICU Network Neurobehavioral Scores, NNNS; Language Environment Analysis, LENA; Adult Word Counts, AWC.

☆ This study was approved by our Institutional Review Board, and the parent of every included newborn provided written informed consent.

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http://dx.doi.org/10.1016/j.jnn.2016.03.003

Introduction

There has long been concern that excessive noise is detrimental to sick newborns in the neonatal intensive care unit (NICU) (Abou Turk et al., 2009; Brown, 2009; Darcy et al., 2008; Lahav and Skoe, 2014; Lasky and Williams, 2009; Wachman and Lahav, 2011). This has prompted interventions such as construction of new single-patient NICU rooms in lieu of open-bay NICU designs (Lester et al., 2011; Stevens et al., 2015). Published benefits of the single-patient room NICU design compared to traditional open-bay NICUs include improved respiratory regulation with fewer apneic events, better growth trajectories, and more favorable NICU Network Neurobehavioral Scores (NNNS), which are predictive of long-term outcomes (Domanico et al., 2011; Lester et al., 2014). Yet, concern remains that preterm infants cared for in single patient NICU rooms may have less favorable developmental language trajectories than those cared for in open-bay units. This may be a particularly important problem among neonates for whom developmental support and maternal involvement are limited during their NICU admission (Caskey et al., 2011; Lester et al., 2014; Pineda et al., 2014).

We hypothesized that infants may experience developmental language delay because of reduced language exposure in the quieter single rooms compared with the open-bay NICU designs in which neonates are exposed to ambient noise and conversation even when their parents or clinical caregivers are not at the bedside. Our main objectives for this analysis were to measure the patterns of sounds to which NICU patients are exposed throughout the day and night, and to specifically evaluate language exposure in a Level IV NICU with single patient rooms.

Methods

This study was approved by our Institutional Review Board, and the parent of every included newborn provided written informed consent. Singleton infants of all gestational ages admitted to our Level IV NICU were eligible for the study. Multiples (e.g. twins, triplets) were excluded due to the potential confound of dividing parents' presence between infants' rooms. A digital language processor was placed on the arm of each infant's isolette. Continuous 16-hour epochs that included both day and night shifts were recorded. "Day" shift was defined as 5 am—9:55 pm, while "night" shift was defined as 10 pm—4:55 am. Proprietary software (lenafoundation.org) was used to extract the cumulative mean and peak sound levels (dB), and the adult word counts (AWC) during the 16-h recording intervals and for 5-min recording epochs. For recordings with low AWC (<50 spoken words per hour), recordings were reviewed by one of the authors (VC) to confirm accurate word counts. The newborns' medical records were systematically reviewed for relevant demographic and clinical data.

Data analysis was implemented via SAS (Cary, NC) and Microsoft Excel (Redmond, WA). Descriptive statistics, independent samples t-tests, and regression models were used to investigate day versus night shift differences in mean and peak sound levels, as well as adult word counts.

Results

Forty newborns were included (22 male; mean gestational age 34.0 ± 5.1, Table 1). Ambient noise levels were consistently above the 45 dB recommended standard (Health, 1997; Lasky and Williams, 2009; White et al., 2013). Average noise level was similar during the day and night shifts (mean 56.1 ± 2.6 dB versus. 54.7 ± 4.2 dB; $p = 0.06$), while peak noise level during the day (85.8 ± 0.7 dB) was somewhat louder than peak noise level during the night (85.0 ± 1.3 dB; $p < 0.001$). Noise levels were not related to SNAPPE-II (illness severity) scores, gestational age, postmenstrual age at the time of recording, or length of hospital stay (regression models, $p > 0.05$ for each association).

Neonates experienced substantial variability in language exposure; AWC ranged from 10 to 2014 spoken words per hour. The median spoken adult word count was 275 per hour (IQR 262). Just 32 ± 1.5% of 5-min recording intervals had *any*

Table 1 Demographic and clinical profile of n = 40 neonates in a level IV neonatal intensive care unit.

Gender	
Male, n (%)	22 (55)
Female, n (%)	18 (45)
SNAPPE-II Score, median (range)	16 (0—82)
Length of Stay (days)[a], median (range)	5 (1—87)
Gestational Age (weeks), mean (SD)	34.0 (5.1)
Birth Weight (grams), mean (SD)	2410 (1070)
Assisted Ventilation, n	7
Mother at bedside — Day shift, n	39
Mother at bedside — Night shift, n	22

[a] Length of stay at the time the acoustic environment was recorded.