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Auditory exposure of high-risk infants discharged from the NICU and the impact of social factors

Lara Lyszka, OTD¹, Elizabeth Heiny, MSOT, OTR/L¹, Joan Smith, PhD², Bradley L. Schlagger, MD, PhD^{3,4}, Amit Mathur, MD⁵, Roberta Pineda, PhD, OTR/L^{1,6}

¹Washington University Program in Occupational Therapy, St. Louis MO

²Saint Louis Children's Hospital Department of Quality, Safety and Practice Excellence, St. Louis MO

³Kennedy Krieger Institute, Baltimore MD

⁴Departments of Neurology and Pediatrics, Johns Hopkins University School of Medicine

⁵Division of Neonatal-Perinatal Medicine, SSM Health Cardinal Glennon Children's Hospital, St. Louis, MO

⁶Department of Pediatrics, Washington University School of Medicine St. Louis, MO

Abstract

Aims: To 1) define the early home auditory environment of high-risk infants within one month of neonatal intensive care unit (NICU) discharge, 2) compare auditory exposures in the home environment to the NICU environment, and 3) define relationships between maternal/infant factors and auditory exposures within the home.

Methods: Seventy-three high-risk infants (48 high-risk infants in the NICU at term-equivalent age and 25 high-risk infants in the home following NICU discharge) had auditory exposures measured.

Results: An average of 1.3 hours more noise ($p = 0.001$) and 2 hours less silence ($p=0.01$) were observed in the NICU compared to the home, but differences varied based on whether comparing to an open ward or private room. Infants with public insurance, lower household income, and mothers without a college education were exposed to an average of 2.8, 3.0, and 2.3 hours more TV/electronic sounds respectively ($p<0.05$). An average of 1,744 fewer adult words ($p=0.03$) were spoken in households with public insurance. There was an average of 3.1 hours less silence and 4.5 dB louder stimuli among households with lower income ($p<0.05$).

Conclusion: Elucidating differences across environments can lead to interventions to foster appropriate auditory exposures to improve language development of high risk infants.

Corresponding Author: Roberta Pineda, PhD, OTR/L, Program in Occupational Therapy, Department of Pediatrics, Washington University School of Medicine, 4444 Forest Park Parkway, St. Louis MO 63110. (314)-286-1304.

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Keywords

Insurance; language; high-risk; preterm; TV

When hospitalized in the neonatal intensive care unit (NICU), high-risk infants experience unnatural acoustics at higher-than-recommended decibel levels (1, 2). Such stimuli also can affect early auditory development (3). Despite the well-documented benefits of human interaction and speech (4), the NICU environment has a paucity of language exposure (5, 6). Better understanding the NICU auditory environment can increase our awareness of how to optimize care among those at risk of language impairment, such as those born preterm (7, 8). However, the time immediately following NICU discharge is also a period of rapid brain development that can be impacted by the early auditory environment (9).

While other work has defined the amount of language infants experience in the home environment as early as 2 months of age (10), there have been no reports (of which we are aware) that quantify auditory and language exposure in infants at or near term-equivalent age. In addition to lack of data on language exposure at home among infants during the neonatal period, it is not well understood how sociodemographic factors impact early auditory exposures. Yet, children with low socioeconomic status have been found to experience delays in language development (11). These delays could be explained, at least in part, by media use and less parent-child verbal interaction, both of which have been reported in households with low socioeconomic status (12). However, it is important to better understand the auditory environment during the neonatal period, and factors that contribute to it, so that interventions can be tailored to what is occurring during this early, impressionable time in development.

This study aims to 1) define the early home auditory environment of high-risk infants at term-equivalent age within one month of NICU discharge, 2) compare auditory exposures in the home environment to the NICU environment, and 3) define relationships between maternal and infant factors and types of auditory exposures within the home environment. We hypothesized that there would be more language exposure in the home environment of high-risk infants within one month of NICU discharge, compared to the NICU environment at term-equivalent age.

Patients and Methods

This study was approved by the Washington University Human Research Protection Office. After receiving detailed information regarding study purpose, risks and benefits, parents signed an informed consent, giving permission to use collected data to understand the early auditory environment. Parents were informed that the audio recordings were aimed to help us better understand the sound environment. Seventy-three infants from two overarching studies were included in this study: high-risk infants during NICU hospitalization (n=48; high-risk NICU) and high-risk infants in the home environment following NICU discharge (n=25; high-risk home).

High-risk NICU group

A previously-enrolled high-risk infant cohort was used for the high-risk NICU group (6) and were enrolled to measure and compare sound exposure to early developmental outcomes. The previous study included recordings across postmenstrual age (PMA). For the purposes of this study, recordings that took place between 36 and 40 weeks PMA were used. The current study expanded the boundaries of term-equivalent age, beyond previous reports (6), to include the final time point prior to infant discharge. Audio recordings were done as early as 36 weeks PMA, as some infants were discharged from the NICU by 37 weeks PMA. The goal was to compare sound exposures at the same developmental time period in the NICU compared to home.

For the high-risk NICU group, forty-eight consecutive admissions of infants born 28 weeks estimated gestational age (EGA; range 23-28 EGA) were recruited from August 2012 to October 2014. Consent was obtained within 72 hours of birth. Infants were excluded if they had a congenital anomaly or failed a hearing screening. All infants were hospitalized in the 85-bed level IV NICU at St. Louis Children's Hospital, St. Louis, Missouri. At St. Louis Children's Hospital, approximately half of the NICU beds were in an open ward, while the other approximately half of beds were contained within private rooms. Due to the differences in sound exposures previously reported in the NICU open ward compared to the NICU private room (6), the NICU room type was also documented. To enable additional comparisons among infants in different NICU environments, infants in the high-risk NICU group were further divided into high-risk NICU open ward (n=24) and high-risk NICU private room (n=24) groups. Parents were able to be present 24 hours a day in the NICU, but were not required to be present during the audio recordings.

High-risk home group:

The high-risk home group consisted of twenty-five infants born preterm, as well as infants with congenital anomalies and other developmental problems who were hospitalized in the NICU. The high-risk home cohort was enrolled as part of a study investigating the impact of programming aimed at improving access to early therapy after NICU discharge. This group consisted of consecutive discharges of infants hospitalized in the 85-bed (which expanded to 125 beds during the course of enrollment) level IV NICU at St. Louis Children's Hospital, St. Louis, Missouri. All infants who met inclusion criteria in this cohort received therapy services (physical therapy, occupational therapy, and/or speech-language pathology) in the NICU and a referral for therapy following discharge. They were enrolled from January 2016 to April 2018 as part of the Baby Bridge Program, a program developed to ensure continuity of therapy services for high-risk infants following NICU discharge. Inclusion criteria for the Baby Bridge Program were infants residing in the St Louis metro area, with parents who spoke English, who were referred for therapy services. As part of this program, infants were recruited prior to NICU discharge, and a therapist visited the infant weekly for therapy services in the home environment until other community-based therapy services commenced. Audio recordings took place between 2 and 48 days after NICU discharge (20.2 ± 12.3 days) and 39-54 weeks PMA (43.1 ± 4.1 weeks PMA) in the infant's home environment.

While audio recordings were intended to occur around the same developmental time period in both groups, during the neonatal period, the PMA at the time of testing was also documented.

Study Procedures

The Language Environmental Acquisition (LENA) device (LENA; LENA Research Foundation, Boulder, Colorado) was used to collect the types and quantity of auditory exposures over one 16-hour period. All audio recordings included in the present study were 16-hours in length. From the audio recordings, LENA Pro Software conducted all quantifications and was used to estimate the amount of time spent with meaningful words, distant words, TV/electronic sounds, noise, and silence, based on the predominant auditory stimulus in the environment during each epoch of time. The LENA defines sound as meaningful words when there is language occurring less than 6 feet away from the infant, whereas it defines sound as distant words when there is language greater than 6 feet away from the infant. TV/electronic noise represents sound from machinery, alarms, music, or television (TV). Other noises, such as rattles, bumps, ambient or white noise, and other non-human auditory exposures, are defined as noise. The LENA software was also used to calculate the peak and average decibel levels of auditory stimuli in the infant's environment, as well as the number of adult words spoken during the 16-hour period. The research team excluded the use of conversational turns from analysis. This was because further investigation of sound identified by the software as conversational turns did not identify responses between infant and caregiver, but rather identified infant grunts, crying and other sounds that did not correspond to reciprocal interaction.

For the high-risk NICU group, the LENA was hung or laid inside a protective pouch on the infant's crib or inside the incubator within two feet of the infant's ears when the infant reached 36-40 weeks PMA. A sign was placed at the bedside to indicate that audio recordings were occurring. LENA recordings started, on average, at 10:00am.

For the high-risk home group, shortly after NICU discharge during one of the therapist's visits to the home, the family was instructed to leave the LENA near the infant in whatever room the baby was to spend the majority of time during the 16-hour recording, which was most frequently the living room or the bedroom. LENA recordings started, on average, at 2:00pm, due to the variation in timing of the arrival of the therapist at the home. The recording commenced at the start of or during the visit by the occupational therapist providing weekly in-home therapy to the infant, and the device stopped recording on its own after the 16-hour period. At the next weekly visit, the therapist retrieved the LENA and exported the data from it.

Infant and social factors:

Infant and social characteristics collected included EGA, infant sex, infant race (African-American or not African-American), NICU length of stay, maternal age, maternal marital status, maternal education (no college degree or college degree), household income (< \$50,000 annual income or to \$50,000 annual income), and insurance type (public or private) as a proxy for socioeconomic status. Differences across the high-risk NICU group

and high-risk home group were explored to define factors to control for in the statistical model. Due to previous studies that have demonstrated that social factors impact language within a child's environment (6), social factors were collected to explore their relationships to auditory exposures during the neonatal period.

Statistical Analyses

Differences in auditory exposure across groups: With 48 infants in the high-risk NICU group and 25 infants in the high-risk home group, this study had 80% power to detect group differences in adult words spoken when the true difference is 1850 words in a 16-hour period ($\alpha = 0.05$).

Log transformations of the LENA outcomes were used to stabilize the variance. Independent samples t-tests were used to explore differences between the amount of time spent with meaningful words, distant words, electronic sounds, noise, and silence, as well as the average and peak decibel level and adult word count between the high-risk NICU and high-risk home groups. Additional analyses using ANOVA were also conducted comparing auditory exposures between the high-risk home and high-risk open ward NICU as well as between the high-risk home and high-risk private room NICU groups.

Differences in infant and social factors across the two groups (NICU and home) were explored using independent samples t-tests and chi-square analyses. Collinearity of factors that were different across groups was assessed using bivariate correlations prior to inclusion in the multivariate statistical model. When $r > 0.30$, the factor identified as being the largest contributor was selected for inclusion in the multivariate statistical model. The multivariate model was used to explore differences in auditory exposure across the two groups, while controlling for infant and social factors that differed across groups, which was determined from group homogeneity analyses. We re-ran analyses including infants in the high-risk home environment only if they had the same inclusion criteria ($n=9$; EGA ≥ 28 weeks and no congenital anomaly) as the high-risk NICU group. We also re-ran analyses controlling for PMA at the time of testing.

Factors related to auditory exposure in the home environment: Independent samples t-tests and one-way analysis of variance were used to explore relationships between LENA measures and social and maternal characteristics of the infants in the high-risk home group. We also re-ran analyses controlling for PMA at the time of testing.

Results

Seventy-three infants (48 high-risk infants in the NICU and 25 high-risk infants in the home) were included in this study.

See Table 1 for the infant and social characteristics of the sample. Infants in the high-risk NICU group had lower EGA ($p<0.01$) and longer length of stay ($p<0.01$), with more infants who were African-American ($p=0.03$) and on public insurance ($p=0.03$) than the high-risk home group. Also the mothers of infants in the high-risk NICU group were younger ($p=0.02$), more likely to be single ($p<0.01$), and more likely to have a college education

($p=0.02$) when compared to the high-risk home group. EGA and LOS ($r=0.55$), EGA and race ($r=0.33$), race and insurance type ($r=0.52$), insurance type and maternal age ($r=0.44$), maternal age and maternal marital status ($r=0.35$), and maternal marital status and EGA ($r=0.37$) were collinear. Therefore, EGA and insurance type were controlled for in the multivariate model.

See Table 2 for the differences in auditory exposures across the high-risk home and high-risk NICU groups as well as additional analyses investigating differences between the high-risk home group and infants in each of the different types of NICU environments. An average of 1.3 hours more noise ($p=0.001$) and 2 hours less silence ($p=0.01$) were observed in the NICU compared to the home. Differences in auditory exposure between home and NICU varied based on whether comparing to an open ward or private room. An average of 3.6 hours less silence ($p=0.003$), 2 hours more electronic sound ($p=0.04$), and an average of 18 minutes more distant language ($p=0.03$) were observed in the NICU open ward compared to the home. When including only infants in the high-risk home environment who had the similar inclusion criteria as the high-risk NICU group, the findings remained largely unchanged. When controlling for PMA at the time of testing, the findings remained largely unchanged.

See Table 3 for infant and social factors that are related to auditory exposures within the home environment. Infants in the high-risk home group with public insurance were exposed to an average of 2.8 hours more TV/electronic sounds ($p=0.02$) and 1,744 fewer adult words ($p=0.03$) than infants with private insurance. Infants with a household income less than \$50,000 experienced on average 3 hours more TV/electronic sounds ($p=0.01$), 3.1 hours less silence ($p<0.001$), and sounds at an average of 4dB higher ($p=0.03$) compared to households with greater than \$50,000 income. Infants with mothers who had did not have a college education were exposed to 2.3 hours ($p<0.001$) more TV/electronic sounds compared to those with mothers who had a college education. When controlling for PMA at the time of testing, the findings remained largely unchanged.

Discussion

The key finding of this study was that there was significantly more noise and less silence in the NICU environment, compared to the home environment of high-risk infants following NICU discharge. However, comparing the home environment to different NICU room types (open ward and private room) enables a better understanding of differences in auditory exposure. There was significantly more TV/electronic sound, fewer adult words spoken, less silence and louder stimuli in the home environment of high-risk infants with higher social risk (public insurance, less household income and less maternal education). Such findings elucidate differences in the NICU, compared to home environment, during the neonatal period and aid our understanding of what factors may be influencing auditory exposures following NICU discharge.

The NICU environment had an average of 1.3 hours more noise and 2 hours less silence in a 16-hour period at term-equivalent age, compared to the home environment of high-risk infants following NICU discharge. This increased exposure in the NICU is consistent with

research that has defined that the auditory environment in the NICU contains machine noise as a significant contributor (6, 13). However, further analyses of auditory exposure, based on room type, demonstrates that there was significantly more distant language exposure in the open ward compared to the home environment. There also was less electronic sound and more silence in the home, compared to the NICU open ward environment. This is consistent with previous reports that identify that auditory exposures differ across different NICU room types (6). Therefore, individualizing auditory interventions, based on environmental factors, may be important.

Our findings demonstrate differences in the home auditory environment among infants with differing socioeconomic status, using insurance type as a proxy (14). This is consistent with other reports identifying that auditory exposures differ among parent-child dyads with different social factors (15). One important component of the auditory environment is electronic sounds. Although the LENA is unable to separate out different types of electronic sounds, the type of electronic sounds captured by the LENA in the NICU are likely beeps from medical equipment and/or from music, and electronic sounds in the home environment were likely from TV and/or from music. While we observed more electronic sounds in the open ward NICU compared to the home environment, social factors can merge with the environment to create different auditory environments for infants once home. Our findings of more TV/electronic sound in the home among those with lower socioeconomic status are consistent with other research that has identified more use of TV among children from parents with less education and income (12, 16). However, these previous reports use samples of children at 6 months of age, compared to the timing of our sample at 39 to 54 weeks PMA, immediately following NICU discharge. Screen time and use of electronics has exponentially increased over the past 10 years, and health professionals are concerned about its effect on pediatric health (17). It has been reported that over 90% of children start watching television before 2 years of age (18); yet, the American Academy of Pediatrics recommends no media exposures before this age (19). TV and media exposures in early childhood have been linked to poor cognitive and language skills at 14 months of age (12, 18). Low socioeconomic status further compounds the effects of media and television exposure in early childhood with links to limited parent-child verbal interactions (16). Our findings of fewer words spoken in the infant's environment among infants with low socioeconomic status are consistent with other literature that reports less verbal communication between parent and child in dyads with high social risk (15). Also of interest is that there appears to be less silence and louder stimuli in households with higher social risk.

The amount of language exposure following NICU discharge appears low, with total language exposure averaging 1.5 hours (or 5,124 words) over a 16-hour period. Language exposures within the first few months of life lay the foundation for language acquisition (20-22). Research has found minimal language exposure in the NICU environment (5, 6); yet, we are not aware of any reports, published or preliminary, of language exposure immediately following NICU discharge. We failed to accept our hypothesis that there would be more language exposure in the home following NICU discharge than in the NICU environment. The LENA Foundation has investigated norms for adult word count totals for infants at 2 months of age, and for the 50th percentile, the normative environment contains

15,439 adult words within a 16-hour period (10). The number of adult words in the home environment of high-risk infants within this study differs significantly from this 50th percentile (-10, 296, 95% CI [-12,335.5, -8257.0]; $p < 0.001$), with 10,296 fewer adult words than the 50th percentile at 2 months of age. This gap in language exposure can aid our understanding of appropriate daily auditory interventions for high-risk infants in the NICU at term-equivalent age and following NICU discharge. It is likely important to determine if interventions designed for medically fragile infants in the NICU who may be unable to tolerate normal sensory experiences may be carried over at home following NICU discharge when no longer appropriate, potentially leading to decreased language exposure and social interactions.

There are limitations of the current study. The LENA device relies on an algorithm that isolates the prevalent stimuli across a 16-hour period, but does not parse out concurrent sounds or background sound. The LENA device also groups TV, electronic sounds, and music under the same outcome measure, complicating its interpretation. There was variability of when each LENA recording was started within and across the groups, which could have changed the outcomes. This creates challenges in interpreting the findings due to the potential impact on daily variation in auditory exposure. The sound exposures in each infant's environment were collected at a single time point, which may not have been representative of the holistic environment. In the home environment, we did not collect which room (i.e. living room, bedroom) where this single time point was collected nor were we able to verify that the LENA device remained in the same room as the infant for the 16-hour period. This single time point around term-equivalent age for the two groups only provides insight into exposures at this period of development following NICU discharge. Another limitation is how the presence of the LENA device may have effected human behavior during the single 16-hour period. This study was conducted in urban St. Louis, and the findings may not generalize to other populations. We are unable to parse whether language exposure increased as the infant showed more engagement with the caregiver or if high-risk infants as a whole receive less language regardless of caregiver interaction. Finally, there are also potential confounds to how insurance type could be related to work hours and access to resources that were not captured within our data collection. Another limitation is that there was no direct measure of maternal or paternal language ability, which is known to impact language exposure (23). This study also included a convenience sample from two overarching studies, and we were not able to ascertain whether parents were present during the recordings. Also, there were differences in infant and social factors across the two groups that could have impacted the outcomes. Despite these limitations, this study is the first, that we are aware of, to assess early home auditory exposures of high-risk infants compared to exposures in the NICU environment at term-equivalent age and explore relationships between these exposures and infant and social factors, sparking further inquiry to define positive auditory interventions within the first year of life for high-risk infants. However, developmental outcomes also depend on other factors such as EGA, presence of severe intraventricular hemorrhage (IVH) or white matter injury, bronchopulmonary dysplasia (BPD), necrotizing enterocolitis (NEC), or sepsis, which need to be adjusted for when assessing the impact of environmental exposures on outcomes (24, 25). This also sparks further interest in understanding the effects of time and duration of parent presence in

the NICU on the auditory environment and understanding differences in behavior among those with different social factors. More research is needed to explore the impact of various types of auditory interventions and supports for families of low socioeconomic status; as well as the effect of such interventions on type and volume of auditory exposures within the first year of life.

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Abbreviations:

LENA	Language Environment Acquisition
NICU	neonatal intensive care unit
PMA	postmenstrual age
TV	television
EGA	estimated gestational age

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Key Notes:

- To date, no study has explored the home auditory environment of high-risk infants following NICU discharge.
- Infants with higher social risk were more likely to hear more TV and fewer adult words.
- More research is needed to explore the impact of various types of auditory interventions and supports for families, especially those with high social risk.

Table 1.

Infant and social factors.

	High-risk NICU Group (<i>n</i> =48)	High-Risk Home Group (<i>n</i> =25)	<i>p</i> value ^{<i>a</i>}
Infant Characteristics	Mean (SD) Range or Median (IQR)	Mean (SD) Range or Median (IQR)	
EGA, <i>weeks</i>	25.7 (1.4) (23-28)	32.2 (4.8) (26-40)	< 0.01
Infant sex, <i>male</i>	30 (63%)	15 (60%)	0.83
Infant race, African-American	28 (58%)	8 (31%)	0.03
NICU length of stay, <i>days</i>	113 (100-140)	60 (14-83)	< 0.01
Maternal Characteristics	N %	N %	
Maternal age, <i>y</i>	28.0 (5.7) (16-40)	31.4 (5.7) (20-42)	0.02
Marital status, <i>single</i>	26 (54%)	4 (15%)	< 0.01
Maternal education, <i>Some college/college degree</i>	16 (36%) ^{<i>c</i>}	11 (52%) ^{<i>b</i>}	0.02
Insurance type, <i>public</i>	27(59%) ^{<i>d</i>}	8 (32%)	0.03
PMA at recording, <i>weeks</i>	37.8 (1.0) (36-40)	43.1 (4.1) (39-54)	< 0.01

^{*a*}P value is from investigating group homogeneity using independent samples t-tests and chi-square analyses^{*b*}
n=21^{*c*}
n=45^{*d*}
n=46

Note: High-risk NICU group defined as NICU auditory environment at term-equivalent age (36-40 weeks PMA) at St. Louis Children's Hospital, Level IV NICU; High-risk home group defined as home auditory environment following NICU discharge of high-risk infants (39-54 weeks PMA)

Table 2.

Characteristics of the home auditory environment.

Over a 16-Hour Period		High-Risk NICU Group at Term equivalent age Mean (h: min) $\pm$ SD	High-Risk Home Group (n=25) Mean (h: min) $\pm$ SD	Mean Difference (h: min)	95% Confidence Interval of the Mean Difference (h: min)	Univariate P value ^a	Multivariate P value ^b
Amount of time spent with meaningful language	Total (n=48)	0:33 $\pm$ 0:23	0:39 $\pm$ 0:27	0:06		0.46	0.17
	Open Ward (n=24)	0:31 $\pm$ 0:23		-0:08	[-0:22, 0:07]	0.30	
	Private Room (n=24)	0:35 $\pm$ 0:25		-0:04	[-0:18, 0:11]	0.80	
Amount of time spent with distant language	Total (n=48)	0:53 $\pm$ 0:53	0:52 $\pm$ 0:53	-0:01		0.38	0.09
	Open Ward (n=24)	1:11 $\pm$ 0:50		0:18	[0.03, 0.54] ^c	0.03	
	Private Room (n=24)	0:36 $\pm$ 0:53		-0:17	[-0.03, 0.18] ^c	0.55	
Amount of time spent with all language (meaningful+ distant)	Total (n=48)	1:27 $\pm$ 1:02	1:31 $\pm$ 1:19	0:05	[-0:27, 0:37]	0.84	0.09
	Open Ward (n=24)	1:42 $\pm$ 1:03		0:10	[-0:27, 0:47]	0.39	
	Private Room (n=24)	1:11 $\pm$ 0:59		-0:21	[-0:57, 0:16]	0.61	
Amount of time spent with TV/ electronic sound	Total (n=48)	3:50 $\pm$ 3:07	3:13 $\pm$ 2:15	-0:36	[-2:00, 0:48]	0.91	0.02
	Open Ward (n=24)	5:19 $\pm$ 3:16		2:05	[0:36, 3:34]	0.04	
	Private Room (n=24)	2:21 $\pm$ 2:07		-0:53	[-2:22, 0:36]	0.07	
Amount of time spent with noise	Total (n=48)	1:49 $\pm$ 2:20	0:31 $\pm$ 1:25	-1:18		<0.001	<0.001
	Open Ward (n=24)	1:31 $\pm$ 1:07		1:00	[0.57, 1.30] ^c	<0.001	
	Private Room (n=24)	2:08 $\pm$ 2:07		1:37	[0.28, 1.01] ^c	0.001	
Amount of time spent in silence	Total (n=48)	8:43 $\pm$ 3:51	10:43 $\pm$ 2:50	2:00		0.01	0.17
	Open Ward (n=24)	7:07 $\pm$ 2:58		-3:36	[-5:29, -1:42]	0.003	
	Private Room (n=24)	10:20 $\pm$ 4:01		-0:23	[-2:17, 1:30]	0.34	
Total number of spoken words around the infant in 16-hour period	Total (n=48)	4,877 $\pm$ 3,848	5,142.8 $\pm$ 4,940.3	265.9		0.94	0.17

Over a 16-Hour Period		High-Risk NICU Group at Term equivalent age Mean (h: min) $\pm$ SD	High-Risk Home Group (n=25) Mean (h: min) $\pm$ SD	Mean Difference (h: min)	95% Confidence Interval of the Mean Difference (h: min)	Univariate P value ^a	Multivariate P value ^b
	Open Ward (n=24)	5,185.5 $\pm$ 4,162.3		42.7	[-2391.9, 2477.3]	0.86	
	Private Room (n=24)	4,568.3 $\pm$ 3,469.1		-574.5	[-3009.1, 1860.1]	0.76	
Average decibels	Total (n=48)	57.2 $\pm$ 2.3	56.4 $\pm$ 4.7	-0.76		0.45	0.84
	Open Ward (n=24)	58.0 $\pm$ 1.9		1.6	[-0.2, 3.5]	0.08	
	Private Room (n=24)	56.3 $\pm$ 2.4		-0.1	[-1.9, 1.7]	0.91	
Highest decibel stimulus	Total (n=48)	87.2 $\pm$ 1.2	86.4 $\pm$ 1.5	-0.83		0.02	0.11
	Open Ward (n=24)	87.1 $\pm$ 1.38		0.8	[0.01, 1.5]	0.05	
	private room (n=24)	7.3 $\pm$ 1.2		0.9	[0.1, 1.7]	0.02	

^aP value is from investigating differences in auditory exposures using independent sample t-tests after log transformation of LENA time measures and adult word count. Additional analyses using ANOVA were used to explore differences between each NICU room type and the home environment.

^bP-value is from investigating differences in auditory exposures using using a multivariate model controlling for EGA and insurance type after log transformation of LENA time measures and adult word count

^crepresents log transformation of data.

Note: High-risk NICU group, both open ward and private room, defined as NICU auditory environment at term-equivalent age (36-40 weeks PMA) at St. Louis Children's Hospital, Level IV NICU; High-risk home group defined as home auditory environment following NICU discharge of high-risk infants (39-54 weeks PMA); bolded values have reached significance of $p < 0.05$; *Note:* All Language is defined as the sum of meaningful language and distant language during the 16-hour period

Table 3.

Relationships between infant and social factors and home auditory exposures following NICU discharge.

	M ± SD	Difference	95% Confidence Interval	P value^a
Insurance Type				
All Language			[-0:42, 1:25]	0.30 ^{**}
<i>Private (n=17)</i>	1:39 ± 0:51	0:31		
<i>Public (n=8)</i>	1:34 ± 0:53			
TV/Electronic Sound			[-0:43, -4:57]	0.02
<i>Private (n=17)</i>	2:19 ± 1:29			
<i>Public (n=8)</i>	5:09 ± 2:28			
Adult Word Count				
<i>Private (n=17)</i>	5,700.9 ± 3,965.5	1,744.2	[0.05, 0.89] ^b	
<i>Public (n=8)</i>	3,956.8 ± 6,735.9			0.03
Household Income⁺				
TV/Electronic Sound				
<i>Income < \$50,000 (n=7)</i>	5:10 ± 1:54	2:59	[1:26, 4:32]	0.01
<i>Income \$50,000 (n=14)</i>	2:11 ± 1:27			
Silence				
<i>Income < \$50,000 (n=7)</i>	8:50 ± 3:12	-3:10	[-5:16, -1:03]	<0.001
<i>Income \$50,000 (n=14)</i>	8:50 ± 3:12			
Average Decibel Stimulus				
<i>Income < \$50,000 (n=7)</i>	59.7 ± 2.85	3.9	[0.41, 7.32]	0.03
<i>Income > \$50,000 (n=14)</i>	8:50 ± 3:12			
Maternal Education⁺				
TV/Electronic Sound				
<i>No college degree (n=14)</i>	3:56	2:16	[0:27, 4:04]	<0.001
<i>College degree (n=7)</i>	1:41			

^aP value is from investigating differences in auditory exposures using independent sample t-tests after log transformation of LENA time measures and adult word count.

⁺n=21

^brepresents log transformation of data

^{**}significant when controlling for PMA (p=0.04)

Note: All Language is defined as the sum of meaningful language and distant language during the 16-hour period