

# Egressed infants from Intensive Care Units: a study in hearing, language and motor responses and the opportunities for the development in the home environment

Lactentes egressos de Unidade de Terapia Intensiva: estudo das respostas auditivas, de linguagem, motoras e as oportunidades para o desenvolvimento motores presentes no ambiente familiar

Infantes egresados de las Unidades de Cuidados Intensivos: estudio de las respuestas auditivas, del lenguaje y motoras y las oportunidades para el desarrollo en el entorno familiar

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## Abstract

**Introduction:** Newborns who experience the NICU environment may have neurological, motor, learning abnormalities and possible developmental disorders. To follow the development of hearing,

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### Authors' contributions:

SAN: Methodology, Article Outline, Data Collection and Critical Review.

DCCS: Study Design, Methodology, Article Outline, Data Collection, Critical Review and Guidance.

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language and motor is fundamental to take appropriate conducts as referrals to specialized services and early intervention. **Objective:** Analyze auditory, language and motor responses and motor development opportunities present in family environment of hearing loss risk infants egress from Neonatal Intensive Care Unit. **Methods:** The sample was composed by 15 infants up to six months corrected age. It was performed behavior hearing evaluation, tympanometry, applied the Bayley-III Scale and the Brazilian version of the Affordances in the Home Environment for Motor Development – Infant Scale questionnaire with parents. The adopted significance level was  $p\text{-value} < 0,05$ . **Results:** All infants presented auditory responses expected for the age group. The correlation between the score of Bayley language and Hearing Loss Risk Indicators was negative ( $r = -0,578$ ,  $p = 0,024$ ) and correlation between the score of Bayley language and Bayley motor was positive ( $r = 0,726$ ;  $p = 0,002$ ). Most of infants are in moderately adequate or less than adequate family environments. **Conclusion:** There was relation between quantity of Hearing Loss Risk Indicators with worse performance in language test development and between higher language score with higher motor score.

**Keywords:** Infant; Child Development; Hearing; Language Development

### Resumo

**Introdução:** Os recém-nascidos que experimentam o ambiente da UTIN podem ter anormalidades neurológicas, motoras, de aprendizagem e possíveis distúrbios do desenvolvimento. O desenvolvimento da audição, da linguagem e motor deve ser acompanhado e é fundamental para tomar condutas adequadas como encaminhamentos a serviços especializados e de intervenção precoce. **Objetivo:** Analisar as respostas auditivas, de linguagem, motoras e as oportunidades para o desenvolvimento motor, presentes no ambiente familiar dos lactentes em risco para deficiência auditiva egressos de Unidade de Terapia Intensiva Neonatal. **Método:** A amostra foi composta por 15 lactentes com até seis meses de idade corrigida. Foi realizada avaliação auditiva comportamental, timpanometria, aplicada a Escala Bayley-III e a versão brasileira do questionário *Affordances* no Ambiente Domiciliar para o Desenvolvimento Motor – Escala Bebê com os pais. O nível de significância adotado foi  $p\text{-valor} < 0,05$ . **Resultados:** Todos os lactentes apresentaram respostas auditivas esperadas para a faixa etária. A correlação entre o escore da Bayley linguagem e quantidade de Indicadores de Risco para Deficiência Auditiva é negativa ( $r = -0,578$ ,  $p = 0,024$ ) e a correlação entre o escore da Bayley linguagem e o escore da Bayley motora é positiva ( $r = 0,726$ ;  $p = 0,002$ ). A maioria dos lactentes está inserida em ambientes moderadamente adequados ou menos do que adequados. **Conclusão:** Houve relação entre maior quantidade de Indicadores de Risco para Deficiência Auditiva com pior desempenho nos testes de linguagem e entre maior escore de linguagem com maior escore motor.

**Palavras-chave:** Lactente; Desenvolvimento Infantil; Audição; Desenvolvimento da Linguagem

### Resumen

**Introducción:** Los recién nacidos que experimentan el entorno de la UCIN pueden tener anomalías neurológicas, motoras, de aprendizaje y posibles trastornos del desarrollo. Seguir el desarrollo de la audición, el lenguaje y la motricidad es fundamental para tomar conductas apropiadas como derivaciones a servicios especializados e intervención temprana. **Objetivo:** Analizar las respuestas auditivas, del lenguaje y motoras y las oportunidades de desarrollo motoras presentes en el entorno familiar de los bebés con riesgo de pérdida auditiva que salen de la Unidad de Cuidados Intensivos Neonatales. **Metodos:** La muestra estuvo compuesta por 15 lactantes de hasta seis meses de edad corregida. Se realizó una evaluación auditiva conductual, timpanometría, se aplicó la Escala de Bayley-III y la versión brasileña del cuestionario *Affordances* in the Home Environment for Motor Development – Infant Scale con los padres. El nivel de significación adoptado fue  $p\text{-valor} < 0,05$ . **Resultados:** Todos los bebés presentaron las respuestas auditivas esperadas para el grupo de edad. La correlación entre la puntuación del lenguaje Bayley y los Indicadores de Riesgo de Pérdida Auditiva fue negativa ( $r = -0,578$ ,  $p = 0,024$ ) y la correlación entre la puntuación del lenguaje Bayley y el motor Bayley fue positiva ( $r = 0,726$ ;  $p = 0,002$ ). La mayoría de los bebés se insertan en entornos familiares moderadamente apropiados o menos que apropiados.

**Conclusión:** Hubo una relación entre la cantidad de indicadores de riesgo de pérdida de audición con peor desempeño en el desarrollo de la prueba de lenguaje y entre la mayor puntuación de lenguaje con mayor puntuación motora.

**Palabras clave:** Lactante; Desarrollo Infantil; Audición; Desarrollo del Lenguaje

## Introduction

Technological advances and the qualification of the health team in perinatal care in Neonatal Intensive Care Units (NICUs) have allowed greater survival of newborns<sup>1</sup>. Newborns who experience the NICU environment may have neurological, motor, learning abnormalities and potential developmental disorders<sup>2,3</sup>. Among the disorders that can occur to these children, there is hearing impairment<sup>4</sup>, in addition to changes in hearing and communication skills in general<sup>5</sup>.

The guidelines to the attention of Newborn Hearing Screening (NHS) indicate that, among live newborns, 10% show Risk Indicators for Hearing Loss (RIHL), and the prevalence of hearing loss varies from 1 to 4:100 newborns treated in NICUs<sup>6</sup>.

Thus, it is evident the need for audiological follow-up after the discharge of these children, which assesses the development of behavioral and linguistic aspects related to the maturation of the pathways and auditory skills<sup>7</sup>. Conducting the follow up for detection and diagnosis of late and/or progressive hearing loss provides the appropriate treatment for the child to develop these skills<sup>8</sup>. The interrelation between global child development and hearing is well-known<sup>7</sup> as well as the importance of the continuity comprehensive care in which language, motor and social aspects of these infants are also assessed<sup>2,7,8</sup>.

Periodic assessment of the progress of each child's motor development is crucial in identifying deviations, and, in cases of premature birth, the child's central nervous and sensorimotor systems are immature and more vulnerable at the beginning of their extra uterine life<sup>9</sup>. Improvement in the motor area is essential for global development, as well as for the process of acquisition and development of speech and language<sup>10</sup>. Children with impairments in speech and language acquisition can trigger problems of communication, social interaction and future school learning<sup>11</sup>. The development of hearing, language and motor skills must be monitored, and it is decisive to take appropriate actions,

such as referrals to specialized services and early intervention.

The environment can interfere in the way in which child development occurs, as the external environment plays a great influence on the child, especially in their first two years of life, when new neural circuits are formed<sup>12</sup>.

The Affordances in the Home Environment for Motor Development-Infant Scale (AHEMD-IS) is an instrument that has been applied in researches that sought to relate family environment to child development<sup>13</sup>. Other areas of development can also benefit from such instrument, as it provides not only practical information about the environmental structure, but also important details about the daily life and interactions among people living in a given environment<sup>13, 14</sup>.

The NHS follow-up clinics at the Center for Studies and Research in Rehabilitation (CEPRE) not only welcome infants who remained in the NICU but they also perform a longitudinal follow-up intermediate care on auditory and language observation of such infants up to the age of two at Hospital/Integrated Center for Women's Health Care Prof. Dr. Aristodemo Pinotti (CAISM), besides, they present strategies to assist families in the development of these infants.

Thus, the objective of this study was to analyze the auditory, language and motor responses, as well as opportunities for motor development present in the family environment of infants up to six months of corrected age and infants at risk of hearing loss that had been discharged from the NICU of a public institution in the city of Campinas.

## Method

This is a cross-sectional and quantitative study. It has been approved by the Research Ethics Committee of UNICAMP, under protocol number 3,617,571. It is an integral part of the project Effect of the Expansion of "Affordances" in the Home Environment in the Development of Infants at Risk of Hearing Impairment.

The sample consisted of 15 infants up to six months of corrected age, who remained in the NICU of CAISM/UNICAMP for more than 48 hours and who attended the first evaluation at the CEPRE/UNICAMP NHS follow-up clinic. The newborns showed results “Passed” in the hearing screening performed with the Automatic Brainstem Auditory Evoked Potential (A-BAEP) and at least one RIHL was observed in the clinical history based on the JCIH<sup>15</sup>. The exclusion criteria for the sample were infants dependent on assisted ventilation, with malformations of the Central Nervous System and diagnosis or investigation of genetic syndromes.

The data collection was completed between April and November 2019. It was performed by an intern speech-language pathologist and a physiotherapy professor. The evaluation was carried out after the guardians of the infants read and signed the Informed Consent Term.

The auditory evaluation was performed by the speech-language pathologist by means of Sound Localization Test realized with rattles and bells, Research of Cochlear-Eyelid Reflex (CER) performed with agogo (a percussion instrument), Visual Reinforcement Audiometry using an Interacoustics® Pediatric Audiometer PA5, and tympanometry with a diagnostic immittance meter Otoflex 100 Otometrics®.

The motor and language development was assessed using the Bayley Scales of Infant and Toddler Development 3rd Edition (Bayley-III), applied by the physiotherapist. Bayley-III is a widely documented instrument that assesses the developmental functioning of children between one and 42 months of age in respect of five development domains: cognitive, language, motor, socioemotional and adaptive behavior<sup>16</sup>. This study analyzed motor and language domains of infants. The performance in each Bayley-III domain is indicated by the composite score (average = 100 and standard deviation = 15)<sup>16</sup>. From the composite score, performance is classified as much higher ( $\geq 130$ ), higher (120-129), high average (110-119), average (90-109), low average (80-89), borderline (70-79) and extremely low ( $\leq 69$ )<sup>16</sup>. For the language and motor analysis, the performance classifications were split into average or above average (composite score  $\geq 90$ ) and below average (composite score  $< 90$ ).

To evaluate the environment and its opportunities that favor the development of infants, the Brazilian version of the Affordances in the Home

Environment for Motor Development-Infant Scale (AHEMD-IS) was used and applied by the two professionals involved in this study. A validated and reliable parental self-report that evaluates opportunities of motor action (affordances) for motor development in the family environment of infants aged 3 to 18 months and consists of 35 items divided into four dimensions: physical space, variety of stimulation, fine motor toys and gross motor toys<sup>14, 17</sup> was also applied. This study used questions related to infants aged 3 to 11 months. The AHEMD-IS questionnaire classifies the environment as: a) less than adequate, b) moderately adequate, c) adequate, d) excellent.

The normality criteria adopted for auditory responses during the follow-up were those proposed by Azevedo<sup>18</sup>. In the classification of Azevedo<sup>18</sup> for infants aged three to six months, the following responses are expected for instrumental sounds: Attention, Search for the sound source and Lateral Sound Localization to the sides. The minimum level of response in Visual Reinforcement Audiometry (pure tones in dB NA) is 60-80 dB. Visual Reinforcement Audiometry is recommended in premature infants only when their corrected age corresponds to 8-10 months<sup>19</sup>. However, for this study, one of the behaviors considered as a response was the orientation reflex, that is, turning the head towards the sound and, in this case, the technique can be used from six months of age<sup>19</sup>. The research of cochlear-eyelid reflex (CER) should occur in 100 dB SPL. In tympanometry, the tympanometric curve type A<sup>20</sup> was considered normal. For verbal sounds, infants are expected to recognize their mother's voice.

The scores of the Bayley-III Scale were scored according to the Technical Manual of Scales for Infant and Toddler Development 3rd edition<sup>16</sup>. Regarding the AHEMD-IS questionnaire, all questionnaires and tables for converting scores into descriptive categories were published in the manuscripts by Caçola et al.<sup>13</sup> for the Brazilian Portuguese version.

All data were compiled into an electronic spreadsheet. Statistical analysis of the data was performed using the Spearman correlation test among the following variables: amount of RIHL, composite score of Bayley language, Bayley motor and total score of the AHEMD-IS questionnaire. The level of significance adopted was p-value  $< 0.05$ , which has been highlighted in bold in the

tables. The analysis were performed using the Minitab software.

## Results

The sample characterization can be seen in Table 1. The 15 participating infants were classified as preterm newborns (PTNB). The gestational age of infants ranged from 24 to 33 weeks with an average age of 30.5 weeks, with only one extremely premature neonate (6.6 %), five (33.3 %) very premature infants and the majority (60%), moderate or borderline preterm infants. As for the

corrected age, it varied between three and four full months. Most parents' schooling ranged between high school (46.6%) and higher education (33.3).

All infants showed expected auditory responses to verbal and non-verbal sounds according to their age. In the evaluation with instrumental sounds, all infants performed the lateral sound localization using rattles and bells; they indicated the occurrence of CER; in visual reinforcement audiometry, they showed a minimum level of response up to 60 dB; in tympanometry, they showed type A tympanometric curve and recognized their mother's voice.

**Table 1.** Characterization of infants

		%	Total (n = 15)
Gender	Male	73.3	11
	Female	26.6	4
GA	<28 weeks	6.6	1
	>28 and <32 weeks	33.3	5
	>32 and <37 weeks	60	9
CA	>3 months and <4 months	26.6	4
	>4 months and <5 months	73.3	11
W	<1000g	13.3	2
	>1001g and <1499g	26.6	4
	>1500g and <2499g	53.3	8
	>2501g	6.6	1

Key 1: n=number of subjects; GA= gestational age; CA=corrected age; W= weight; g=gram.

Table 2 shows the performance of infants regarding motor and language areas. On the Bayley-III scale, in respect of language development, 8/15 (53.3%) of infants are on average or above average

and 7/15 (46.6%) are below average. In terms of motor development, 11/15 (73.3%) infants are on average or above average and 4/15 (26.6%) are below average.

**Table 2.** Results obtained by infants using the Bayley-III Scale

	Average or Above average n (%)	Below average n (%)	Total n = 15
Language	7 (46.6%)	8 (53.3%)	15 (100%)
Motor	11 (73.35%)	4 (26.6%)	15 (100%)

Key 2: n=number of subjects.

The results of the AHMED-IS questionnaire that indicate the quantity and quality of affordances in the family environment demonstrated that 4/15 (26.6%) infants are inserted in environments suitable for motor development, while 7/15 (74.6%) of them are inserted in moderately adequate environments and 4/15 (26.6%) in less than adequate environments. None of the infants 0/15 (0%) were within an environment considered to be excellent.

Correlation analysis showed that the amount of RIHL to which infants were exposed to was significantly correlated with performance in Bayley language score ( $r = -0.578$ ;  $p = 0.024$ ), and performance in Bayley language score was also correlated with performance in Bayley motor score ( $r = 0.726$ ;  $p = 0.002$ ), as shown in Table 3. The data related to the infants' family environment were not statistically significant.

**Table 3.** Results of the correlation between risk indicators for hearing loss (RIHL), Bayley-III Scale and AHMED-IS Questionnaire

	<b>IRHL Qty.</b>	<b>Lgg. Bayley Score</b>	<b>Mot. Bayley Score</b>
Lgg. Bayley Score	-0.578 0.024*	- -	- -
Mot. Bayley Score	-0.277 0.317	0.726 0.002*	- -
AHEDM-IS Score	0.133 0.638	-0.380 0.162	-0.159 0.572

Key 3: Qty. =quantity; Lgg.=language; Mot.=motor.

The correlation between the Bayley language score and the amount of RIHL was negative, that is, the higher the number of RIHL, the lower the score of the Bayley language scale. The correlation between the Bayley language and motor scores was positive, that is, the higher the Bayley language score, the higher the Bayley motor score.

The data in Table 4 indicate the quantity and description of each RIHL, the performance of

each infant in the evaluations carried out, the parents' responses regarding their schooling, and the responses to the AHMED-IS questionnaire. The participants showed at least one RIHL, ranging from two to four indicators, and the only common indicators to all infants were the concern of their guardians in respect of the development of hearing and the stay in ICU/NEO or semi-intensive care for more than five days.



**Table 4.** Detailed results for each infant

RIHL	Mother's Sch.	Father's Sch.	Hearing	B.Lgg.	B.Mot.	AHEMD-IS Quest.
S1 - (3) Family concern, stay in NICU for more than 5 days and ototoxic medication	E/M	H.S.	Adequate	Average	Ab. average	Adequate
S2 - (4) Family concern, stay in NICU for more than 5 days, congenital infections and ototoxic medication	H.S.	E/M	Adequate	Average	Average	Mod. Adequate
S3 - (3) Family concern, stay in NICU for more than 5 days and heredity	Col.	H.S.	Adequate	B. Average	Average	Mod. Adequate
S4 - (3) Family concern, stay in NICU for more than 5 days and congenital infections	E/M	E/M	Adequate	B. Average	Average	Mod. Adequate
S5 - (4) Family concern, stay in NICU for more than 5 days, hyperbilirubinemia and ototoxic medications	Col.	H.S.	Adequate	B. Average	Average	Less Adequate
S6 - (2) Family concern and stay in NICU for more than 5 days	Col.	H.S.	Adequate	B. Average	Average	Mod. Adequate
S7 - (2) Family concern and stay in NICU for more than 5 days	H.S.	Col.	Adequate	Ab. average	Average	Less Adequate
S8 - (2) Family concern, and stay in NICU for more than 5 days	H.S.	Col.	Adequate	Average	Average	Less Adequate
S9 - (2) Family concern, and stay in NICU for more than 5 days	H.S.	Col.	Adequate	Average	B. Average	Less Adequate
S10 - (2) Family concern and stay in NICU for more than 5 days	E/M	E/M	Adequate	Average	Ab. average	Adequate
S11 - (2) Family concern and stay in NICU for more than 5 days	Col.	Col.	Adequate	Border	Border	Adequate
S12 - (3) Family concern, stay in NICU for more than 5 days and ototoxic medications	H.S.	Col.	Adequate	Average	Average	Mod. Adequate
S13 - (3) Family concern, stay in NICU for more than 5 days and ototoxic medications	H.S.	Col.	Adequate	Average	Average	Mod. Adequate
S14 - (3) Family concern, stay in NICU for more than 5 days and heredity	Sup.	H.S.	Adequate	B. Average	B. Average	Mod. Adequate
S15 - (4) Family concern, stay in NICU for more than 5 days, neonatal asphyxia and ototoxic medications	H.S.	Col.	Adequate	B. Average	B. Average	Adequate

Key 4: RIHL = Risk Indicator for Hearing Loss; Sch.= schooling; E/M = elementary and middle school; H.S.= high school; Col. = college; B.Lgg.=Bayley Language Scale; B.Mot.=Bayley Motor Scale; Quest.=questionnaire; ICU= Intensive care unit; NICU = Neonatal intensive care unit; Border.=Borderline; B.Average= Below Average; Mod. Adequate= Moderately Adequate; Ab. Average=Above Average; Less Adequate= Less than Adequate.

## Discussion

In this study we could verify that all infants had adequate auditory development. In the range of three to four months – corrected age of the participants –, the following responses were considered to be behavioral reactions to sound stimuli: cochlear-eyelid reflex, eye movement, lateral sound localization, increased or decreased pacifier sucking, smiling, crying, attention, fright, frowning, generalized body movements, among others<sup>18</sup>. Infants up to six months of corrected age showed an expected response in the evaluation of audiological follow-up. These findings corroborate the literature<sup>22,23,24</sup>, which indicates a low rate of inadequate follow-up results, as the expected behavioral responses for the age group are considered low complexity, in addition to different types of responses being accepted as positive to the stimuli.

The results of the Bayley-III Scale tests show that the most altered development domain was that of language, with more than half of the results below average. The findings in the literature show that children born prematurely or with low weight are at greater risk of presenting delays in language development<sup>25</sup>. According to the data that associated the highest amount of RIHL with the worst performance in language tests, some researches claim that the presence of RIHL can influence the development of the infant and culminate in a possible delay in the maturation of auditory skills and language development<sup>24</sup>.

Ribeiro and Beltrame<sup>26</sup>, when assessing the neuromotor and biopsychosocial characteristics of infants with a history of biological risk, observed that they may present variable impairment in relation to aspects of neuromotor development. In the data found, only four infants showed motor development below average, which can be explained by the same factors resulting from prematurity.

The quality of home environment is relevant to development, and the vast majority of environments were considered to have low stimulation opportunities. Environmental factors can positively or negatively influence child development and being aware of them allows to make suggestions for interventions, with the aim of reducing the effects of these factors on children and families<sup>25,27</sup>. For environments classified as less than adequate or moderately adequate, it is suggested that families expand or add aspects to the home environment,

such as increasing the daily time of parents' interaction/play with the infant, more freedom of movement/exploration of the environment, and make age-appropriate toys available, offering a variety of opportunities that can promote the development of the infant.

Relationships between broad motor and language development have been reported<sup>2,5</sup>. In addition, the literature points to a close connection between motor, cognition and language acquisitions in infants up to two years of age<sup>2,4,9</sup>. Frezzato et al.<sup>28</sup> demonstrated that a child has difficulties in language acquisition because it is a process of a multidetermined nature. A change involved in the maturation of motor skills can have implications for language acquisition<sup>9,11,12</sup>. The results of the current study contribute to reinforce the impact of motor skills on the language and communication skills of infants.

The number of RIHL shown in the clinical history of infants ranged from two to four. Most researches on premature neonates have a single RIHL or a maximum of five indicators<sup>29</sup>. Regarding the occurrence of RIHL, the common indicators to all infants were the concern of their guardians in respect of hearing development and the stay in NICU or semi-intensive care for more than five days, followed by the use of ototoxic medication (aminoglycosides). The most frequently indicator recorded in the study by Pinto et al.<sup>30</sup> was the use of ototoxic medication, followed by NICU stay >5 days. An important aspect to be considered is that indicators may vary according to the characteristics of each service, for example, in services that are of reference for pregnant women and high-risk newborns, as in the case of this study, there will be more indicators.

Some limitations of this study were the small sample size and the fact that the Bayley Scale used has not yet been standardized for the Brazilian population. Despite these limitations, behavioral methods enable the multidisciplinary team to globally assess the development and they can be purchased and applied at a lower cost.

After the complete evaluation, the booklet "Daily activities for infant stimulation" was given to the infants' guardians, with guidance on how to stimulate the development of their babies through simple activities using three toys (rattle, book and stacking pots), which were also provided. The study continues and counts on the reassessment of these



infants after one and two months of stimulation with the activities.

## Conclusion

The current study analyzed the performance of preterm infants discharged from NICUs for auditory, motor and language skills, and environmental opportunities for their development. The infants presented expected auditory responses. There was relationship between a greater amount of RIHL with worse performance in language tests and between higher language and motor scores. The contribution of this study to strategies in the surveillance of the global development of infants with RIHL is emphasized, including the assessment of the home environment.

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