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# Risk indicators for hearing loss and language acquisition and their relationship with socioeconomic, demographic and obstetric variables in preterm and term babies

## *Indicadores de risco para a deficiência auditiva e aquisição da linguagem e sua relação com variáveis socioeconômicas, demográficas e obstétricas em bebês pré-termo e a termo*

### Keywords

Hearing  
Language  
Child Development  
Risk Factors  
Premature Birth

### Descritores

Audição  
Linguagem  
Desenvolvimento Infantil  
Fatores de Risco  
Nascimento Prematuro

### ABSTRACT

**Purpose:** To compare the frequency of risk indicators in preterm and full-term babies; to analyze the possible relationships among the presence of risk for hearing loss with language acquisition and socioeconomic, demographic and obstetric variables. **Methods:** This is a longitudinal cohort study, with a sample of 87 babies. Gestational, obstetric and sociodemographic data were collected from mothers and babies. The socioeconomic classification status of the families were classified using the Brazilian Criteria for Economic Classification. The risk for language was assessed using the Language Acquisition Enunciation Signs and the Denver II test. The data were analyzed using the STATISTICA 9.1 software, using the chi-square and the Mann-Whitney U tests and simple and multiple linear regression models. **Results:** Permanence in a neonatal intensive care (65.52%), ototoxic (48.28%), mechanical ventilation (39.66%) and hyperbilirubinemia (46.55%) were the more frequent risk indicators in the sample. Regarding socioeconomic, demographic and obstetric factors, there was a correlation among prenatal care, gestational age, birth weight, feeding with hearing risk. Acquisition and development of language showed statistical significance with varicella, HIV, Apgar score and birth weight >1500 grams. **Conclusion:** Preterm babies showed higher frequency of risk indicators compared to full-term babies. Among environmental factors, prenatal care, which interferes in the outcome of gestational age, birth weight, Apgar score and presence of infectious diseases, as well as feeding, emerged as significant factors related to hearing and language acquisition. Prematurity was the relevant biological factor related to hearing and language risk.

### RESUMO

**Objetivo:** Comparar a frequência de indicadores de risco em bebês nascidos pré-termo e a termo; analisar as possíveis relações entre a presença de risco para perda auditiva com variáveis socioeconômicas, demográficas, obstétricas e risco à linguagem. **Método:** Trata-se de um estudo de coorte longitudinal com amostra de 87 bebês. Foram coletados dados gestacionais, obstétricos e sociodemográficos das mães e dos bebês. A classificação socioeconômica das famílias foi analisada por meio do Critério de Classificação Econômica Brasil. O risco à linguagem foi avaliado por meio dos Sinais Enunciativos de Aquisição da Linguagem e Teste Denver II. Os dados foram analisados utilizando o programa STATISTICA 9.1, por meio dos Testes Quiquadrado e U de Mann-Whitney, Modelo de regressão linear simples e múltiplo. **Resultados:** A permanência em UTI neonatal (65,52%), ototóxico (48,28%), ventilação mecânica (39,66%) e hiperbilirrubinemia (46,55%) foram os indicadores de risco mais frequentes na amostra. Considerando fatores socioeconômicos, demográficos e obstétricos, houve correlação entre pré-natal, idade gestacional, peso ao nascer e alimentação com o risco auditivo. A aquisição e desenvolvimento de linguagem mostrou significância estatística com a varicela, HIV, Apgar e peso >1500 gramas. **Conclusão:** Os prematuros apresentaram maior frequência de indicadores de risco, comparados aos bebês a termo. Dos fatores ambientais, o pré-natal que interfere no desfecho da idade gestacional, peso ao nascer, apgar e presença de doenças infecciosas, além da alimentação, despontaram como significativos relacionados com o desenvolvimento da audição e a aquisição da linguagem. A prematuridade foi o fator biológico relevante relacionado ao risco auditivo e linguístico.

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## INTRODUCTION

The integrity of the auditory system is essential for the development of auditory skills and language acquisition. The Joint Committee on Infant Hearing is an international committee that proposes recommendations on children's hearing health. This committee understands that risk indicators for hearing loss are prenatal, perinatal and postnatal complications that can cause auditory changes in the child<sup>(1)</sup>. Thus, only one indicator in the child's clinical history is considered a warning sign of auditory risk and the presence of more than one indicator increases the probability of hearing loss. Hence, proper care with the auditory health of these subjects is important.

Nationally, the Multiprofessional Committee on Hearing Health (COMUSA) reinforces international recommendations for hearing impairment detection and intervention. COMUSA promotes discussion and implementation of specific actions related to hearing health, being a reference in implementing Neonatal Hearing Screening (NHS) in Brazil<sup>(2)</sup>. More recently, the Ministry of Health elaborated Newborn Hearing Screening Care Guidelines, aiming to describe the methodology to be adopted, as well as offering guidance to multidisciplinary teams for the hearing health care in childhood, especially for the Neonatal Hearing Screening<sup>(3)</sup>. NHS was defined as a set of actions that should be performed for comprehensive hearing health care, including screening, monitoring and follow-up of hearing and language development, diagnosis and (re)habilitation<sup>(3)</sup>.

The Risk Indicators for Hearing Loss (RIHL) considered in this article prioritized national literature, with emphasis on: parents' concern about child development, hearing, speech or language; family history of hearing loss; prematurity; birth weight less than 1500 grams; stay in the Intensive Care Unit (ICU) for more than five days; use of ototoxic medication; use of mechanical ventilation; hyperbilirubinemia; craniofacial anomalies involving ear and temporal bone; syndromes associated with hearing loss; congenital infections (syphilis, toxoplasmosis, rubella, cytomegalovirus, and human immunodeficiency virus-HIV); head trauma; chemotherapy; postnatal bacterial or viral infections (cytomegalovirus, herpes, measles, varicella and meningitis); Apgar from 0 to 4 in the 1st minute or from 0 to 6 in the 5th minute<sup>(3)</sup>, as well as alcoholism or drug use during pregnancy<sup>(4)</sup>.

It is essential that newborns and infants with RIHL receive monitoring and follow-up regarding hearing development, in order to reduce health harm in these babies, as well as to provide adequate language acquisition and development.

Considering the vulnerability of at-risk babies, infant hearing health has been working in the implementation of programs that envision promotional actions, assessment, diagnosis and early intervention for newborns and infants<sup>(5)</sup>. There is also concern about developing actions in primary care, such as training of community health agents prioritizing the development of skills related to children's hearing health<sup>(6)</sup>.

In relation to health promotion, the World Health Organization International Conference, held in Ottawa in 1986, recognizes health promotion as the process of empowering the community to work on improving their quality of life, as well as meeting needs and changing the environment in a way that is favorable

to the individual's health. The prerequisites for health are represented by fundamental conditions and resources such as: peace; shelter; education; food; income; a stable eco-system; sustainable resources; social justice and equity<sup>(7)</sup>.

Obstetric health factors (type of delivery, number of prenatal consultations, gestational planning, birth weight, gestational age and the type of baby feeding); demographic aspects (maternal age, occupation, educational level, marital status and number of children); socioeconomic and cultural aspects influence maternal and child health. Therefore, the relationship between these factors and the babies' hearing and language is the topic of this article. Socioeconomic, obstetric and demographic issues may act as a protective or as a risk factor for the development of infants in the first years of life<sup>(8)</sup>. It is also shown in the literature that the success of NHS programs, which are important for the early detection of hearing loss, is directly related to the social and economic conditions of the population being assisted<sup>(9)</sup>.

Therefore, the objectives of the present study were: to compare the frequency of RIHL in a sample of preterm and full-term babies; to analyze the possible relationships between the presence of RIHL and socioeconomic, demographic, obstetric variables and the risk to language acquisition.

## METHODS

### Study design and sample

The present study is a longitudinal cohort, part of a research project entitled "Comparative Analysis of the Development of Preterm and Full-term Infants and The Relationship to Psychic Risk: from Detection to Intervention", in which 140 babies born preterm and full-term have records of longitudinal follow-up in relation to psychism, language, hearing, cognition and psychomotricity from one month to 24 months of age. The study has approval from the Research Ethics Committee of the university where it was carried out, under the protocol n° 652.722.

In order to convene the sample of the present study, a consultation was made to the database of the project to which this study is linked, from where preterm and full-term born babies were selected according to the following criteria: were included in the sample subjects having one or more of the Risk Indicators for Hearing Loss (RIHL) and whose family members signed a Free and Informed Consent Form. Subjects who did not meet such criteria were excluded from the sample. The final sample consisted of 87 babies, followed longitudinally from 0 to 12 months.

Preterm has been defined as babies born before 37 weeks of pregnancy, and full-term has been defined as babies born between 37 and 42 weeks of pregnancy, following the World Health Organization classification<sup>(10)</sup>. For the application of assessment instruments, corrected age was used for preterm infants and chronological age was used for term infants.

### Data collection and analysis

Data collection was conducted from the selected subjects, including an interview with the parents and application of the assessment instruments, described as follows:

1) **Initial Interview:** The parents of the babies answered a semi-structured interview that approached sociodemographic data, through the use of plain questions. This interview also investigated the babies' obstetric, gestational and birth data, as well as aspects of eating, sleeping and language. Interview data were supplemented by consulting the children health records and hospital discharge summaries, in case of hospitalization during the first days of life. It was possible to characterize the RIHL of all the babies included in the study. For RIHL, hyperbilirubinemia was considered present when in a mother's report or in a discharge summary there was reference to the presence of jaundice, indicating level for phototherapy or exsanguination transfusion.

Continued interviews were conducted in each return to language assessments, in order to update and supplement babies' data. Thus, continued interviews were important to classify the type of infant feeding as: breastfeeding, if until six months the baby was still receiving breast milk; mixed, if the baby received supplement by formula in addition to breast milk; and formula, if the baby was no longer being breastfed.

2) **The Brazilian Criteria of Economic Classification (CCEB):** The CCEB was utilized to collect socioeconomic data, through the Initial and Continued Interviews. Consideration was given to data on ownership of assets, family income and level of education of the household's head person, and a score was assigned for each item, according to the instrument<sup>(11)</sup>. The CCEB is used to analyze socioeconomic issues, since it is a system of price classification for the Brazilian population, not classifying people in terms of social classes, but rather dividing the market exclusively into economic classes, based on the possession of assets, not based on family income. For each asset possessed, there is a score and each class is defined by the sum of this score. The classes are defined by the CCEB, based on the score of the instrument, resulting in an estimate of the average household income as follows: A (R\$ 20,888), B1 (R\$ 9,254), B2 (R\$ 4,852), C1 (R\$ 2,705), C2 (R\$ 1,625), D-E (R\$ 768)<sup>(11)</sup>.

3) **Language Acquisition Enunciation Signs (SEAL):** This instrument aims to detect early stages of inaccuracies in the acquisition of language using signs whose theoretical basis is the Benvenistean enunciation. For this, it uses the indicatory paradigm, that is, when signs or indications that a symptom of language may be organizing itself, are absent. When present, they are positive signs that indicate that language acquisition is occurring adequately<sup>(12)</sup>. It is considered a language risk when there are two or more missing signs, per phase, and five or more in the total of two years. The SEAL is divided into Phase 1, which encompasses the age range of 3 months to 6 months and 29 days and Phase 2, encompassing the age of 7 months and 1 day to 12 months and 29 days. In Phase 1 eight signs are investigated and in Phase 2 four signs are investigated<sup>(12)</sup>. The application of the SEAL is conducted through the filming of the interaction of mother-baby. Mothers are asked to sing, to talk and to play

with their baby. The examiner assigns a value of present or absent for the items of the SEAL on the same day of filming. In case of doubt, the filming may be used for further analysis of the signs by another experienced examiner in the area of language. This study considered evaluation data of babies in phases 1 and 2 of SEAL, who were evaluated at 3 months, 6 months, 9 months and 12 months.

4) **DENVER II:** This test is divided into four areas, comprising 125 items. Only the Language Area was used, which has 39 items and assesses the production of sounds, the ability to recognize, understand and use the language. The test is applied directly with the child, as well as through response requests by the mother or responsible caregiver. Taking into consideration the age range of the test, the following aspects of language per phase were included: Phase 1 (from 3 to 4 months) – if the baby responds to a bell, vocalizes and shouts; Phase 2 (from 6 to 7 months) – if the baby turns to a voice command, emits monosyllables, makes simulations of speech sounds, produces non-specific “mom / dad”; Phase 3 (from 8 to 9 months) – if the baby combines syllables; Phase 4 (from 11 to 12 months) – if the baby produces specific “mom / dad” and one word. That scale was applied to babies from 3 to 12 months, covering all stages of the instrument considered important for the study objectives.

Microsoft Excel 2010 program was used for data analysis, and the data was tabulated in a program spreadsheet. Regarding the socioeconomic data, the CCEB total score was utilized, as well as the economic classes, estimated by the subjects' household income. Demographic data included the following variables: maternal age, occupation, maternal educational level, maternal marital status and number of children. Obstetric data included: type of delivery, number of prenatal consultations, gestational planning, birth weight, gestational age and the type of infant feeding.

Regarding the RIHL, the number of indicators present for each subject was tabulated, as well as the types of indicators present in the population studied. For the SEAL, the number of items present in phase I (eight signs) and phase II (four signs) was tabulated. In the DENVER II test, the percentage levels of the number of items present in each phase of the test were tabulated, considering the classification proposed in the test, in the following levels: normal (90% to 100%), doubtful (75% to 89%) and altered (below 74%). Therefore, the test items were considered after following the age group up to 12 months at the baseline of the test and the correct answers of each subject in the study were scored in percentages.

After inserting all variables into the database, statistical analysis was performed using the STATISTICA 9.1 program. The following statistical tests were used: Chi-square test and Mann-Whitney U test, using a p value less than 0.05. Finally, the relationship between RIHL and socioeconomic, demographic and obstetric variables was analyzed using the Simple and Multiple Linear Regression Model at a significance level of 5%.

## RESULTS

Table 1 shows the results related to the frequency of RIHL in the study sample. The sample consisted of 87 infants with RIHL, of which 58 (66.7%) were in the preterm born babies group and 29 (33.3%) in the full-term born group.

Table 1 shows that the most frequent RIHL in preterm babies were neonatal ICU stay for more than five days (65.52%), followed by ototoxic medication (48.28%), use of mechanical ventilation (39.66%) and hyperbilirubinemia (46.55%). Variables related to frequencies in relation to weighing less than 1500 grams (17.24%); neonatal ICU stay for more than five days (41%); the use of ototoxic medication (32%) and mechanical ventilation (25%) were statistically significant compared to the group of full-term babies. For infants born full-term, the most frequent RIHL were hyperbilirubinemia (37.93%), Apgar altered at the 1st or 5th minute (17.24%), presence of toxoplasmosis (4 infants)

and varicella (2 infants), the last two were statistically significant, differentiating full-term babies from preterm babies.

Hyperbilirubinemia is an important factor in both groups (46.55% of preterm babies and 37.93% of full-term babies). Prenatal diseases, such as toxoplasmosis, syphilis, varicella and HIV were more common among full-term babies.

The babies in the present study had at least one risk indicator for hearing loss and a maximum of seven associated indicators. Table 2 shows that there was a statistically significant association between diet and total RIHL. These results showed that babies that were fed with breast milk had a protective factor for the auditory risk.

The variables economic class, maternal education, marital status, occupation, planning and childbirth, did not show statistical significance. However, it is possible to observe that maternal education had an influence on lower number of auditory risk indicators. For the other economic variables, it was observed that most families are considered relatively low income, being

**Table 1.** Frequency of Risk Indicators for Hearing Impairment (IRDA) in preterm and full-term infants

IRDA	PRETERM	FULL-TERM	TOTAL	P VALUE
	N (%)	N (%)	N (%)	N (%)
<b>Family history for hearing loss</b>				
YES	8 (13.79%)	4 (13.79%)	12	1.000
NO	50 (86.21%)	25 (86.21%)	75	
<b>Birth weight &lt; 1.500g</b>				
YES	10 (17.24%)	0 (0.00%)	10	0.003*
NO	48 (82.76%)	29 (100.00%)	77	
<b>NICU stay</b>				
YES	38 (65.52%)	3 (10.34%)	41	< 0.001*
NO	20 (34.48%)	26 (89.66%)	46	
<b>Use of ototoxic medication</b>				
YES	28 (48.28%)	4 (13.79%)	32	< 0.001*
NO	30 (51.72%)	25 (86.21%)	55	
<b>Use of mechanical ventilation</b>				
YES	23 (39.66%)	2 (6.90%)	25	< 0.001*
NO	35 (60.34%)	27 (93.10%)	62	
<b>Hyperbilirubinemia</b>				
YES	27 (46.55%)	11 (37.93%)	38	0.443
NO	31 (53.45%)	18 (62.07%)	49	
<b>Toxoplasmosis</b>				
YES	1 (1.72%)	4 (13.79%)	5	0.026*
NO	57 (98.28%)	25 (86.21%)	82	
<b>Syphilis</b>				
YES	1 (1.72%)	3 (10.34%)	4	0.080
NO	57 (98.28%)	26 (89.66%)	83	
<b>Varicella</b>				
YES	0 (0.00%)	2 (6.90%)	2	0.034*
NO	58 (100.00%)	27 (93.10%)	85	
<b>HIV positive</b>				
YES	2 (3.45%)	2 (6.90%)	4	0.481
NO	56 (96.55%)	27 (93.10%)	83	
<b>Apgar altered</b>				
YES	6 (10.34%)	5 (17.24%)	11	0.371
NO	52 (89.66%)	24 (82.76%)	76	
<b>Drug use during pregnancy</b>				
YES	11 (18.97%)	4 (13.79%)	15	0.540
NO	47 (81.03%)	25 (86.21%)	72	

Chi-square test

**Captions:** \*p < 0.05; Yes / No: Means having risk or not in the mother and baby health history; NICU: Neonatal Intensive Care Unit, considering the stay of the baby for more than 5 days; Apgar altered: it is considered altered when the score is 0 to 4 in the 1st minute or 0 to 6 in the 5th minute



in classes C1, C2 and D-E, which gave certain homogeneity of the sample in this regard. There are more married mothers than single mothers. We also observed a greater number of mothers who worked outside the home, a large majority who did not plan the pregnancy, and had a caesarean delivery.

Regarding the obstetric variables number of prenatal care visits, birth weight and gestational age, the descriptive statistical analysis results showed that, for preterm babies, the average of prenatal care visits was 6.6, the average birth weight was 2047.1 grams, and the average gestational age was 33.6 weeks; while for full-term babies, the average of prenatal care visits was 8.4, the average birth weight was 3212.4 grams, and the average gestational age was 39.1 weeks.

Table 3 shows the analysis using the Simple and Multiple Linear Regression Models. Socioeconomic variables (economic class defined by the CCEB score), demographic variables (maternal age, education, occupation, marital status and number of children) and obstetric (type of delivery, number of prenatal consultations, gestational planning, birth weight, gestational age and maternal breastfeeding) were independently tested with the RIHL outcome in the model.

The Simple Linear Regression Model showed that the variables prenatal, birth weight, gestational age and maternal breastfeeding presented a significant correlation with the RIHL outcome. The other variables were excluded from the model because they did not correlate with the RIHL.

The Simple Model also shows a negative  $\beta$  value for prenatal, gestational age and birth weight. Thus, the higher the RIHL, the lower the score of these variables. Therefore, a higher risk for hearing correlates with a lower number of consultations during prenatal care, prematurity and low birth weight.

Additionally, the RIHL is directly proportional to the score for breastfeeding, because the  $\beta$  coefficient of the model is positive. Therefore, breastfeeding was confirmed as a protective factor for hearing risk, as presented in Table 2.

Using the Multiple Linear Regression Model, Table 3 shows the significant correlation between prenatal and gestational age variables with RIHL. The model obtained an  $R^2$  coefficient of 0.565, therefore it cannot be used for estimation, since it does not reflect appropriately the quality of fit of the model to the data ( $RIHL = 17.104 - 0.095 * \text{prenatal score} - 0.054 * \text{gestational}$

**Table 2.** Association between number of IRDA and socio-demographic variables, type of delivery, pregnancy planning and neonatal feeding

Variables		N	IRDA Total		
			Mean + Standard deviation	Median	p-value
Economic Class	A	0	0.00 + 0.00	0.00	0.564
	B1 e B2	1	3.00 + 0.00	3.00	
	C1 e C2	33	3.03 + 1.84	3.00	
	D-E	49	2.77 + 1.80	2.00	
Education Level	Elementary	23	3.21 + 1.90	3.00	0.327
	High school	48	2.77 + 1.77	2.00	
	University	12	2.66 + 1.77	2.00	
Marital Status	Single	15	3.13 + 1.64	3.00	0.399
	Married	68	2.82 + 1.84	2.00	
Occupation	Housewife	39	3.00 + 1.79	2.00	0.558
	Works outside the home	42	2.83 + 1.84	3.00	
Pregnancy Planning	Yes	37	3.02 + 1.70	3.00	0.370
	No	46	2.76 + 1.88	2.00	
Type of Delivery	Normal	27	3.00 + 2.13	2.00	0.992
	Cesarean section	56	2.82 + 1.64	3.00	
Feeding	Breast Milk	36	1.88 + 1.21	1.50	0.001*
	Formula	27	4.03 + 1.99	5.00	
	Mixed	20	3.10 + 1.44	3.00	

Mann-Whitney U test

**Captions:** \*p < 0.05; N: Number of subjects for each variable; mixed: breast milk feeding and formula

**Table 3.** Correlation between IRDA and the independent variables: prenatal, gestational age, birth weight and feeding in the neonatal period

Independent variables	Simple Linear Regression Model	
	B	p-value
Prenatal	-0.193	0.001*
Gestacional age	-0.054	0.000*
Birth weight	-0.001	0.000*
Breastfeeding	0.074	0.002*
Independent variables	Multiple Linear Regression Model	
	B	p-value
Prenatal	-0.095	0.027*
Gestacional age	-0.054	0.000*

**Captions:** \*p < 0.05; R2 = Quality of the model Coefficient; Simple and Multiple Linear Regression Model.  $\beta$  = Beta Coefficient

age). However, the model can be used to explain that the variables prenatal, and gestational age are jointly correlated to the RIHL, or explaining the RIHL. The lower the number of consultations during the prenatal period as well as the gestational age, the greater the risk for hearing loss.

Table 4 shows the association between the types of RIHL and language acquisition through the SEAL and Denver II Test.

The variables varicella, HIV and Apgar had a statistically significant association with the DENVER phase 1. The variable weight lower than 1500 grams had a statistically significant association with SEAL 2 and DENVER phase 2.

Table 5 shows the mean, standard deviation, and median values of the association between RIHL types and language acquisition through the SEAL and Denver II test. The SEAL 1 had little influence from the RIHL. For SEAL 2, in addition to the birth weight, the variables syphilis, HIV and drug use during pregnancy were associated with the lowest mean score, showing that the presence of these indicators in the health history of the babies in the sample, influenced the acquisition of language in the second half of life. In addition, the variables weight below 1500 grams and toxoplasmosis had mean levels corresponding to the altered results in DENVER phase 2 and phase 4, respectively.

**Table 4.** Association between IRDA and Language

IRDA	SEAL 1	SEAL 2	DENVER 1	DENVER 2	DENVER 3	DENVER 4
	p-value	p-value	p-value	p-value	p-value	p-value
<b>Family history for hearing loss</b>	0.770	0.487	0.067	0.968	0.612	0.987
<b>Birth weight &lt; 1.500g</b>	0.119	0.046*	0.407	0.000*	0.661	0.897
<b>NICU stay</b>	0.670	0.152	0.758	0.932	0.125	0.633
<b>Use of ototoxic medication</b>	0.486	0.277	0.912	0.336	0.291	0.165
<b>Use of mechanical ventilation</b>	0.356	0.768	0.177	0.956	0.706	0.873
<b>Hyperbilirubinemia</b>	0.732	0.924	0.470	0.552	0.838	0.461
<b>Toxoplasmosis</b>	0.253	0.890	0.211	0.621	1.000	1.000
<b>Syphilis</b>	0.177	0.083	0.128	0.350	0.670	0.338
<b>Varicella</b>	0.803	0.910	0.012*	1.000	1.000	1.000
<b>HIV positive</b>	0.591	0.340	0.012*	1.000	1.000	1.000
<b>Apgar altered</b>	0.730	0.638	0.035*	0.410	0.940	0.726
<b>Drug use during pregnancy</b>	0.593	0.438	0.125	0.162	0.412	0.63

Mann-Whitney U-Test

**Captions:** \*p < 0.05; NICU: Neonatal Intensive Care Unit, considering the stay of the baby for more than 5 days; Apgar altered: it is considered altered when the score is 0 to 4 in the 1st minute or 0 to 6 in the 5th minute

**Table 5.** Mean, Standard Deviation and Mean Deviation of the Association between IRDA Variables and Language

IRDA		SEAL 1		SEAL 2		DENVER 1		DENVER 2		DENVER 3		DENVER 4	
		M+SD	Med	M+SD	Med	M+SD	Med	M+SD	Med	M+SD	Med	M+SD	Med
<b>Family history for hearing loss</b>	YES	6.75+1.54	7.00	2.80+1.22	3.00	96.00+1.22	100.00	95.83+6.25	100.00	95.00+9.25	100.00	88.88+22.04	100.00
	NO	6.33+2.18	7.00	2.42+1.48	3.00	98.23+10.21	100.00	94.75+9.81	100.00	88.80+21.05	100.00	88.82+23.20	100.00
<b>Birth weight &lt; 1.500g</b>	YES	5.55+2.45	5.00	1.42+1.61	1.00	100.00+0.00	100.00	71.87+15.72	75.00	80.00+3.25	100.00	87.50+25.00	100.00
	NO	6.50+2.04	7.00	2.59+1.39	3.00	97.68+10.59	100.00	96.59+6.11	100.00	90.18+19.19	100.00	88.94+22.90	100.00
<b>NICU stay</b>	YES	6.51+2.03	7.00	2.21+1.53	2.00	98.88+4.64	100.00	94.19+11.52	100.00	93.84+14.71	100.00	87.03+25.35	100.00
	NO	6.29+2.17	7.00	2.72+1.34	3.00	97.14+12.93	100.00	95.56+6.88	100.00	86.25+22.96	100.00	90.51+20.50	100.00
<b>Use of ototoxic medication</b>	YES	6.67+1.83	7.00	2.20+1.47	2.00	98.62+5.15	100.00	92.61+12.59	100.00	93.68+14.98	100.00	95.23+12.79	100.00
	NO	6.23+2.24	7.00	2.62+1.43	3.00	97.55+11.99	100.00	96.28+6.49	100.00	87.69+21.82	100.00	85.00+26.56	100.00
<b>Use of mechanical ventilation</b>	YES	6.78+1.70	7.00	2.42+1.42	3.00	100.00+0.00	100.00	92.50+14.79	100.00	92.00+16.56	100.00	89.06+20.34	100.00
	NO	6.25+2.22	7.00	2.50+1.47	3.00	97.24+11.51	100.00	95.73+6.57	100.00	88.83+21.06	100.00	88.75+23.98	100.00
<b>Hyperbilirubinemia</b>	YES	6.22+2.34	7.00	2.44+1.45	2.00	96.57+14.13	100.00	94.90+11.10	100.00	88.14+23.04	100.00	86.00+27.08	100.00
	NO	6.53+1.90	7.00	2.50+1.46	3.00	99.06+4.26	100.00	94.92+7.68	100.00	90.96+17.00	100.00	91.12+18.87	100.00
<b>Toxoplasmosis</b>	YES	5.80+1.78	6.00	2.33+1.52	2.00	96.00+8.94	100.00	93.75+8.83	93.75	100.00+0.00	100.00	50.00+0.00	50.00
	NO	6.43+2.12	7.00	2.48+1.45	3.00	98.08+10.09	100.00	94.95+9.40	100.00	89.47+20.03	100.00	89.54+22.40	100.00
<b>Syphilis</b>	YES	6.00+0.81	6.00	1.25+0.50	1.00	95.00+10.00	100.00	87.50+17.67	87.50	90.00+14.14	90.00	75.00+35.35	75.00
	NO	6.41+2.14	7.00	2.55+1.45	3.00	98.10+10.00	100.00	95.17+9.07	100.00	89.64+20.17	100.00	89.35+22.57	100.00
<b>Varicella</b>	YES	7.00+1.41	7.00	2.50+0.70	2.50	90.00+0.00	90.00	87.50+0.00	87.00	80.00+0.00	80.00	100.00+0.00	100.00
	NO	6.38+2.11	7.00	2.47+1.47	3.00	98.15+9.89	100.00	95.04+9.34	100.00	89.82+20.04	100.00	88.63+22.98	100.00
<b>HIV positive</b>	YES	6.66+0.57	7.00	1.50+0.70	1.50	90.00+14.14	90.00	75.00+0.00	75.00	0.00+0.00	0.00	0.00+0.00	0.00
	NO	6.38+2.13	7.00	2.50+1.46	3.00	98.15+9.89	100.00	95.25+9.01	100.00	89.65+19.90	100.00	88.83+22.82	100.00
<b>Apgar altered</b>	YES	6.18+2.27	7.00	2.75+1.28	3.00	88.88+26.66	100.00	97.91+5.10	100.00	91.42+15.73	100.00	95.00+11.18	100.00
	NO	6.43+2.08	7.00	2.44+1.47	3.00	99.13+4.10	100.00	94.57+9.65	100.00	89.41+20.53	100.00	88.23+23.63	100.00
<b>Drug use during pregnancy</b>	YES	6.73+2.01	7.00	2.10+1.72	1.50	96.66+7.78	100.00	98.61+4.16	100.00	94.28+15.11	10.00	78.12+24.77	87.50
	NO	6.32+2.12	7.00	2.54+1.40	3.00	98.18+10.36	100.00	94.25+9.84	100.00	89.01+20.51	100.00	90.62+22.25	100.00

**Captions:** M+SD: Mean+Standard Deviation; Med: Median. NICU: Neonatal Intensive Care Unit, considering the stay of the baby for more than 5 days; Apgar altered: it is considered altered when the score is 0 to 4 in the 1st minute or 0 to 6 in the 5th minute

## DISCUSSION

The results of the present study show a high percentage of babies with risk indicators for hearing loss, considering the database of the project to which this article links, where 87 out of 140 babies presented one or more RIHL (62.14%). The high percentage of babies with RIHL (66.7% of preterm babies and 33.3% of full-term babies) may be associated with environmental and socio-demographic factors that may aggravate the health conditions of the study subjects. It is not possible to generalize such findings to the entire Brazilian population, since it is a study that characterizes the south region of the country. Among the study environmental factors, the precariousness of prenatal care, shown in the small number of consultations during pregnancy (6.6 for preterm and 8.4 for full-term babies), and the presence of infectious diseases, are particularly noteworthy, which is associated with low birth weight and prematurity.

It is known that the presence of risk indicators increases the probability of hearing impairment. Thus, children with risk indicators in their health history have a prevalence of hearing loss ranging from 0.3% to 20.68%, and it is essential that they receive auditory monitoring in the first years of life<sup>(13)</sup>. The high percentage of children with RIHL in the present study is a public health concern in the region.

The most frequent risk indicators for preterm babies in this sample were: neonatal ICU stays for more than five days (65.52%), followed by ototoxic medication (48.28%), use of mechanical ventilation (39.66%) and hyperbilirubinemia (46.55%). For full-term babies, the most frequent indicators were hyperbilirubinemia (37.93%) and Apgar at the 1st and 5th minute (17.24%).

A study conducted with preterm babies assigned in three groups: gestational age < 28 weeks; between 29 and 32 weeks and those with gestational age > 32 weeks, analyzed the incidence of auditory risk indicators among this population. The results of that study corroborates with the data of this investigation since it was found that the frequency of RIHL in the preterm group < 28 weeks was the following: weight < 1500 grams (92.23%); use of ototoxic medication (70.87%); stay in neonatal ICU for more than five days (66.54%) and use of mechanical ventilation (57.45%). For the group of preterm infants aged between 29 and 32 weeks the most frequent RHDI were: ototoxic medication use (60.39%); weight < 1500 grams (40.16%); neonatal ICU stay for more than five days (36.25%) and use of mechanical ventilation (23.38%). For the preterm sample > 32 weeks a frequency of 1.72% was found for ototoxic medication<sup>(14)</sup>.

The literature shows that aspects related to preterm birth, such as gestational age, low birth weight and other complications at birth can negatively influence hearing maturation and language acquisition<sup>(15,16)</sup>. Therefore, health promotion actions and clinical follow-ups for children considered at risk, especially with prematurity in their health history, are important to enable adequate auditory and linguistic development.

It is important to emphasize hyperbilirubinemia as a factor present in both groups, born preterm (46.55%) and full-term term (37.93%), demonstrating that it is a factor to be controlled as it can be harmful to the auditory system. The literature emphasizes

that hyperbilirubinemia is considered a toxic condition for the auditory system and central nervous system, which may increase the risk of autism, hearing loss, auditory neuropathy and encephalopathy<sup>(17)</sup>.

A study showed hyperbilirubinemia as a common risk indicator (28.83%), in a population of 702 infants. The proportion of failure in neonatal hearing screening was higher in the subjects with the presence of hyperbilirubinemia (8.38%) compared to subjects without this risk indicator (6.35%)<sup>(18)</sup>.

Prenatal diseases, such as toxoplasmosis, syphilis, varicella and HIV were more common among full-term babies, compared to preterm babies. These data suggest that such diseases, in percentages ranging from 6.9% to 13.7% in the group of babies born at full-term and from 1.72% to 3.45% in the group born pre-term must be investigated in the prenatal period. Therefore, it is important for mothers to perform prenatal consultations more frequently and for investments to be made in the region which the research was conducted in order to reduce these diseases in the population, through preventive campaigns and ongoing educational programs to the population, especially among the youth and adults sexually active.

It is possible that due to the socioeconomic and cultural homogeneity of the sample, no association between these variables and the RIHL was found. However, a similar result was observed in a study that aimed to analyze the association between socioeconomic, demographic, neonatal and perinatal factors and “failure” in neonatal hearing screening in 1272 infants. The results of that study found a significant association between altered screening and family history for hearing loss as well as the parents’ “race”. The authors found no significant association between the variables gender, gestational age, birth weight, maternal age, parity, prenatal, type of delivery, risk of hyperbilirubinemia, feeding of the baby, having health insurance and family income with “failure” in the auditory screening<sup>(19)</sup>.

In relation to the socioeconomic status, studies show an influence on the performance of children in auditory evaluation tests. Low economic and cultural statuses are associated with greater risk of change in auditory processing, language deficits and learning<sup>(20)</sup>. Socioeconomic status and maternal educational level influence mother-child linguistic interaction, and expressive and understanding language<sup>(21)</sup>. Low maternal educational level is associated with delayed child development and children’s restricted vocabulary<sup>(22)</sup>. Some authors also associate caesarean delivery with greater risk of failure in neonatal hearing screening tests<sup>(23)</sup>.

Furthermore, another study<sup>(24)</sup> showed that babies with risk indicators for hearing loss had a development below the expected average for the age group, and that the home environment was insufficient, in relation to favorable opportunities to the development of babies with RIHL. Perhaps, in the age group in which the babies of this study were assessed, it is still not possible to detect important changes between these variables and language acquisition.

It is important to acknowledge the data on infant feeding that had statistical significance with the association between breastfeeding and total RIHL. A correlation in the simple linear model was also showed; indicating that breastfeeding may be

a protective factor to auditory risk. This can be explained by the fact that breastfeeding configures biological protection effect due to the presence of immunoglobulins. Breastfeeding is also associated with a lower incidence of otitis, protecting the middle ear from infections, when compared to feeding with artificial milk<sup>(25)</sup>. Additionally, breastfeeding strengthens the interaction between mother and baby, assisting in the mother's interpretation of the baby's demands, increasing the moments of protoconversation and linguistic interaction between the mother-baby duo<sup>(26)</sup>.

The results from the linear regression model showed that the lower the number of prenatal consultations, the lower the gestational age, and the greater the hearing risk. Prenatal care is essential to welcome mothers, to monitor the development of babies and to ensure the well-being of both mother and baby. This maternal-fetal care is essential to guide healthy habits, to prepare for childbirth, to prevent, to diagnose and to treat gestational conditions and to reduce the rate of maternal-infant morbidity and mortality<sup>(27)</sup>. WHO recommends a minimum of eight prenatal care visits for better maternal and child health care<sup>(10)</sup>.

Low prenatal care adherence has a negative impact on maternal and child health, increasing the risk for neonatal illness and premature birth. The lack of maternal prenatal care may be associated with low income and low educational level, unemployment and lack of access to health services, as well as maternal depression and anxiety<sup>(27)</sup>. Teenage pregnancy is also associated with poor adherence to prenatal care, increasing maternal-fetal health risks. Maternal age is another important factor shown in the literature associated with risk of child development, since adolescent mothers present a higher incidence of preterm births, low birth weight, higher smoking rates, and poor adherence to screening tests during gestation<sup>(28)</sup>. In this study sample, no associations were found in this regard.

Regarding the association between language and RIHL, the results showed a statistical significance for the variables varicella, HIV and Apgar with DENVER phase 1. The variable weight below 1500g showed statistically significance with SEAL 2 and DENVER phase 2. It was also observed for the SEAL 2 that, besides the variable weight, the variables syphilis, HIV and drug use during pregnancy are associated with the lowest mean score. The variables weight below 1500g and toxoplasmosis presented mean levels corresponding to the altered result in DENVER phase 2 and phase 4, respectively. Thus, it can be inferred that Apgar, drug use in pregnancy and low birth weight may be interfering with language acquisition.

These findings corroborate other studies that showed an association between low birth weight, manifested by prematurity, poorer performance in language assessment tests, and delayed language acquisition and development<sup>(29)</sup>. With regards to Apgar, one study showed that altered values in Apgar were associated with later development of Specific Language Disorders (SLD) in children<sup>(30)</sup>. Contrarily, the diseases varicella, HIV, syphilis and toxoplasmosis are harmful to the auditory system, increasing the probability of hearing loss, which can translate into difficulties in language acquisition and development.

Finally, the small sample was pointed out as a limitation of the study, as it makes it impossible to generalize the results to the reality of the entire Brazilian population, characterizing the study as regional, presenting more specifically the reality of part of the south region of Brazil. The small sample also made it difficult to analyze preterm babies in subgroups, divided by gestational age. That division would enrich the discussion about risk indicators for language by comparing full-term babies with extremely, moderate and late preterm babies. Another limitation is that language assessments cannot be applied beyond the first year of life, which would provide more data to better discuss the interference of RIHL in language acquisition and development of preterm and full-term babies.

## CONCLUSION

The present study found a high prevalence of risk indicators for hearing loss (RIHL) in the sample, with a higher risk frequency in the preterm babies group. Preterm birth was considered to be the risk factor for language development and maturation of the most relevant auditory abilities. The most frequent RIHL were neonatal ICU stay for more than five days (65.52%), use of ototoxic medication (48, 28%), use of mechanical ventilation (39.66%) and hyperbilirubinemia (46.55%).

The results of the study showed that prenatal care is essential to prevent a number of conditions that lead to risk of hearing loss and language. It also showed that the high prevalence of infectious diseases and prematurity in the sample may be associated with the precariousness of health at the research site, which may place maternal and child health at risk. Regarding risk for language, there was interference in the linguistic evolution in cases of: diseases such as varicella, HIV, syphilis and toxoplasmosis, low birth weight and drug use during pregnancy.

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### Author contributions

*GBN participated in the idealization of the study, data collection, analysis and interpretation and article writing; IC and ABM participated in the statistical analysis and data interpretation; TMK and APRS, as advisor and co-advisor, participated in the idealization of the study, data analysis and interpretation and review of the manuscript.*