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Research Article

# Predictors of Vocabulary Outcomes in Children Who Are Deaf or Hard of Hearing From Spanish-Speaking Families

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**Purpose:** The goal of this study was to identify predictors of expressive vocabulary in young Spanish-speaking children who are deaf or hard of hearing living in the United States.
**Method:** This cross-sectional study considered 53 children with bilateral hearing loss between 8 and 34 months of age ($M$ = 24, $SD$ = 6.9). Demographic variables, variables related to the hearing loss, and intervention variables were included in a hierarchical regression analysis to predict expressive vocabulary quotients from the MacArthur Inventario del Desarrollo de Habilidades Comunicativas (Communicative Development Inventories; Jackson-Maldonado et al., 2003).
**Results:** Chronological age, degree of hearing loss, functional hearing ability ratings, age of enrollment in early intervention, and the interaction between chronological age and age of intervention accounted for 61.5% of the vocabulary variance. Children who received intervention by 6 months of age achieved significantly higher vocabulary outcomes than children who started intervention later.
**Conclusion:** The children's mean vocabulary outcomes were below average when compared with hearing peers. This was especially true for older children, children with moderately-severe-to-profound hearing loss, and children who began intervention after 6 months of age. This delay in vocabulary outcomes has the potential to interfere with future reading and academic outcomes.

Spanish is the second most common language spoken in the homes of children who are deaf or hard of hearing (DHH) in the United States. The Gallaudet Research Institute (2013) survey found that 19.4% of children who are DHH live in homes where Spanish is spoken. This includes children in both monolingual Spanish environments as well as children whose families use varying proportions of Spanish, English, and/or sign language. The number of children who are DHH from Spanish-speaking families will continue to grow considering that the Hispanic population in the United States is expected to increase from 17.4% to 28.6% by 2060 (Colby & Ortman, 2015).

The academic achievement of Spanish-speaking children who are DHH in the United States is lower than that of their Caucasian and African American DHH peers (Allen, 1986; Kluwin & Gonsher, 1994; Marschark, Shaver, Nagle, & Newman, 2015). Expressive vocabulary has been identified as an important predictor of reading and academic achievement among monolingual and bilingual hearing children from a variety of language backgrounds, including Spanish speakers (Proctor, Carlo, August, & Snow, 2005; Proctor, Silverman, Harring, & Montecillo, 2012). This relationship has also been documented in children who are DHH (Connor & Zwolan, 2004; Kyle, Campbell, & MacSweeney, 2016). Thus, identifying early predictors of expressive vocabulary in DHH children may help identify early causes of future reading and academic delays. The current study aims to identify predictors of expressive vocabulary outcomes in Spanish-speaking children who are DHH living in the United States.

## *Bilingualism in Children Who Are DHH*

Families and professionals use different approaches to communicate with children who are DHH. These approaches vary in terms of the degree of spoken and sign languages used (Moeller, Carr, Seaver, Stredler-Brown, & Holzinger, 2013). For example, families and professionals may use spoken

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language only, sign language only, or a combination of spoken and sign languages. In addition, some families may speak a language other than English at home. According to the last report from the Gallaudet Research Institute (2013), the reported language(s) regularly used in the home of children who are DHH in the United States are English (81.6%), Spanish (19.4 %), American Sign Language (ASL; 9.5%), and others (15.6 %).[1] The combination of the home language(s) with the communication approach may result in children being exposed to two or three languages. Children who are DHH from Spanish-speaking families, for example, may be exposed to Spanish, the minority language used at home; English, the majority language in the community; and/or ASL (or signs from ASL to support spoken Spanish) used in the intervention and at home. Although many children who are DHH are part of Spanish-speaking families, research on speech and language development in children who are DHH who speak Spanish (only or in combination with other languages) is still in the early stages (Bunta & Douglas, 2013), especially for children between birth and 3 years of age.

Multilingual children who are DHH can pose a challenge for professionals when assessing language outcomes and when providing intervention. Previous research in bilingual (English–Spanish) children with normal hearing has shown that, if children receive enough exposure to both languages and vocabulary scores are combined, bilingual children's vocabulary scores are comparable with those observed in monolingual peers (e.g., Core, Hoff, Rumiche, & Señor, 2013; Hoff, Rumiche, Burridge, Ribot, & Welsh, 2014; Pearson, Fernández, & Oller, 1993). However, children may have smaller vocabularies in each of their languages, and thus, reporting outcomes in only one of the languages may overidentify bilingual children as having a language delay (Genesee, Paradis, & Crago, 2004; Hoff et al., 2014). It has been suggested that children with disabilities or language impairments should be assessed and treated in their home language (Restrepo, Morgan, & Thompson, 2013; Yim, 2012).

Identifying children who are delayed in their home language is important, in part, because bilingual children who are not proficient in their home language will have limited interpersonal relationships with their family members, which results in negative effects on social development (Kohnert, Yim, Nett, Kan, & Duran, 2005). In addition, previous research has found that supporting a child's home language has a positive impact on the acquisition of the second language, as language skills are transferred from one language to the other (e.g., Dickinson, McCabe, Clark-Chiarelli, & Wolf, 2004; López & Greenfield, 2004). Thus, to the greatest extent possible, professionals should support home language competency and assess language outcomes considering all the languages that the child is exposed to (Kohnert et al., 2005; Restrepo et al., 2013). However, assessing both languages can be challenging due to the scarcity of assessment tools that include bilingual norms, especially for children under 3 years of age.

[1]Percentage may total to more than 100.0 because multiple responses were allowed.

## *Predictors of Language Outcomes*

Previous research with English-speaking DHH children indicates that maternal educational level (Calderon, 2000; Ching et al., 2010, 2013; Yoshinaga-Itano, Baca, & Sedey, 2010), age of identification of the hearing loss (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998), age of enrollment in early intervention (e.g., Meinzen-Derr, Wiley, & Choo, 2011; Vohr et al., 2011; Watkin et al., 2007; Yoshinaga-Itano et al., 2010), and age of amplification and implantation (Ching et al., 2013; Markman et al., 2011; Niparko et al., 2010; Quittner, Cejas, Wang, Niparko, & Barker, 2016; Sininger, Grimes, & Christensen, 2010) predict language outcomes. As far as we know, parallel research has not been conducted with Spanish-speaking children who are DHH, where the effect of the predictors may be different considering factors traditionally associated with Latino families in the United States, such as low maternal education, low socioeconomic status (SES), and limited access to intervention and resources (Kohler & Lazarín, 2007; Ryan & Bauman, 2016; Wolbers, 2002).

### Socioeconomic Level and Maternal Education

Hearing children from birth to 3 years of age who are from low-SES backgrounds often experience diminished language input and enter school at a disadvantage in language development that may persist throughout their education (Hart & Risley, 1992; Hoff, 2003; Hoff, Laursen, Tardif, & Bornstein, 2002; Leffel & Suskind, 2013). In addition, for low-SES children who are DHH, caregivers' struggles with basic needs, such as housing, food, medical care, transportation, or child care, could interfere with the family's ability to be consistent with intervention. Niparko et al. (2010) found that higher SES was associated with greater rates of improvement in comprehension and expression in 188 English-speaking children with cochlear implants (CIs) aged 9–60 months. Other studies have included maternal education as a proxy for SES and have found that higher maternal educational levels relate to higher language outcomes in English-speaking (Calderon, 2000; Ching et al., 2010, 2013; Quittner et al., 2016; Yoshinaga-Itano et al., 2010; Yoshinaga-Itano, Sedey, Wiggin, & Chung, 2017) and German-speaking children with hearing loss (Holzinger, Fellinger, & Beitel, 2011). For example, Quittner et al. (2016) found that maternal education was significantly related to symbolic play and noun learning tasks in 180 children with CIs with an average age of 2.2 years; however, other studies that included maternal education as a predictor of language did not find a significant effect (Vohr et al., 2008, 2011). This is probably because, in these studies, the majority of the mothers had a bachelor's degree or higher levels of education.

In the case of Latino families in the United States, maternal education and SES may play less of a role in predicting language outcomes considering that only 15.5% of

the population has a bachelor's degree or higher (Ryan & Bauman, 2016) and 32% of children under 3 years of age live in poverty (Jiang, Granja, & Koball, 2017). Given that maternal education has historically been considered a predictor of language outcomes and different results have been reported depending on the population studied, we considered it an important variable to include in the current study.

**Degree of Hearing Loss**

Hearing loss, even mild hearing loss, limits access to auditory information necessary to develop speech and language and subsequent social and academic skills in children (Tharpe, 2008; Tomblin et al., 2015). Previous research on the impact of degree of hearing loss on language outcomes in English-speaking children who are DHH seems to differ, depending on whether children were identified before or after the establishment of universal newborn hearing screening (UNHS). Interestingly, the majority of studies considering children identified before UNHS did not find an effect of degree of hearing loss on language outcomes when intervention was provided early in life (Mayne, Yoshinaga-Itano, & Sedey, 1999; Mayne, Yoshinaga-Itano, Sedey, & Carey, 1999; Meinzen-Derr et al., 2011; Moeller, 2000; Yoshinaga-Itano & Apuzzo, 1998). For example, Yoshinaga-Itano and Apuzzo (1998) found that early-identified and aided children with mild to profound hearing loss had similar language outcomes in the first 3 years of life. Similarly, Moeller (2000) found that degree of hearing loss did not predict vocabulary skills in 112 five-year-old children if early intervention was provided by 11 months of age.

Recent studies with children identified through UNHS programs show an effect of degree of hearing loss, suggesting that children with less severe degrees of hearing loss achieve higher language outcomes (Ching et al., 2010, 2013; Holzinger et al., 2011; Sarant, Holt, Dowell, Rickards, & Blamey, 2008; Sininger et al., 2010; Vohr et al., 2008, 2011; Yoshinaga-Itano et al., 2017). For example, Vohr et al. (2011) found that children with moderate to profound hearing loss had significantly lower vocabulary outcomes than children with minimal to mild hearing loss, even when receiving intervention as early as 3 months of age. These differences in results across studies pre- and post-UNHS could be due to the different ages, language measures, and predictors considered or the populations included in the studies: United States (e.g., Mayne, Yoshinaga-Itano, Sedey, & Carey, 1999; Meinzen-Derr et al., 2011; Moeller, 2000; Sininger et al., 2010; Vohr et al., 2011; Yoshinaga-Itano et al., 2017), Austria (Holzinger et al., 2011), and Australia (Ching et al., 2010, 2013; Sarant et al., 2008).

**Age of Identification of Hearing Loss**

Several studies have found that an early age of hearing loss identification and intervention results in improved language outcomes (Lin et al., 2011; Meinzen-Derr et al., 2011; Watkin et al., 2007; Yoshinaga-Itano et al., 1998, 2010). Identification by 6 months of age has been shown to provide an advantage to language outcomes regardless of communication mode, degree of hearing loss, SES, gender, minority status, or presence of additional disabilities (Yoshinaga-Itano et al., 1998). Holzinger et al. (2011) found that age of diagnosis and amplification did not predict language outcomes in 63 Austrian children with hearing aids (HAs) between the ages of 2;4 and 7;10 (years;months); only age of enrollment in intervention showed a significant effect. However, the age of hearing loss identification, HA fitting, and early intervention were highly intercorrelated (from .77 to .99), and many children were identified with hearing loss after 6 months of age ($M$ = 9.3 months, $SD$ = 11.9 months). Research addressing this issue with a large language minority group, such as Spanish-speaking children who are DHH, has not yet been conducted.

**Age of Amplification and Use of Devices**

Tomblin et al. (2015) conducted a longitudinal study with 317 children between 6 months and 7 years of age who had mild-to-severe hearing loss. They examined the relationship between degree of hearing loss and outcomes across several developmental domains. Findings from this study showed that children with mild-to-severe hearing loss were at risk for delayed language development and the risk increased with the severity of unaided hearing levels. Children with well-fitted HAs, however, had a reduced risk of language delays, possibly because HAs provided better access to spoken language. Similarly, Sininger et al. (2010) found that age of HA fitting was a strong and significant predictor of receptive and expressive language outcomes in 44 infants and toddlers with hearing loss. In contrast, Ching et al. (2010) found no effect of age of HA fitting in 133 three-year-old Australian children, where parental education and degree of hearing loss were the only factors predicting language outcomes.

In the case of children with CIs, recent studies agree that an early age of implantation (before 2 years) results in higher speech perception and language outcomes when compared to late-implanted children (Ching et al., 2013; Markman et al., 2011; Niparko et al., 2010; Quittner et al., 2013, 2016). For example, Ching et al. (2013) found that the age of CI activation was significantly associated with better language outcomes in 451 three-year-old children. In addition, a young age of implantation contributes to age-appropriate spoken language skills even after 8.6 years of CI use (Geers & Nicholas, 2013).

**Age of Intervention**

Previous studies suggest that an early age of enrollment in intervention results in higher language outcomes (Holzinger et al., 2011; Lin et al., 2011; Mayne, Yoshinaga-Itano, & Sedey, 1999; Mayne, Yoshinaga-Itano, Sedey, & Carey, 1999; Meinzen-Derr et al., 2011; Moeller, 2000; Quittner et al., 2016; Vohr et al., 2008, 2011; Watkin et al., 2007). Moeller, before UNHS, found that children who enrolled earliest in intervention, by 11 months of age, showed better vocabulary outcomes at 5 years of age than children who enrolled later. Vohr et al. (2011), after UNHS, found that children with hearing loss without additional disabilities enrolled in early intervention by 3 months of age had a

larger expressive vocabulary than children enrolled later and that early-enrolled children demonstrated the greatest growth in vocabulary from 12 to 16 and from 18 to 24 months of age. Whether these results generalize to Spanish-speaking children in the United States has yet to be determined.

## Purpose

The purpose of this exploratory study was to identify predictors of expressive vocabulary quotients as measured by the MacArthur Inventario del Desarrollo de Habilidades Comunicativas (Communicative Development Inventories; IDHC; Jackson-Maldonado et al., 2003). It was hypothesized that, as found in previous research with English-speaking children with hearing loss, maternal educational level, degree of hearing loss, and the age of hearing loss identification, amplification, and intervention would predict vocabulary outcomes in Spanish-speaking children who are DHH.

Expressive vocabulary was selected as the outcome measure in this study because of the importance of this aspect of language given its strong relationship with reading comprehension in hearing and DHH children, including native English and native Spanish speakers (Connor & Zwolan, 2004; Kyle et al., 2016; Proctor et al., 2005, 2012). In addition, numerous studies on predictors of expressive vocabulary have been conducted with English-speaking children with hearing loss, providing a basis of comparison to the results of the current investigation with children from Spanish-speaking families.

## Method

### *Participants*

Families participating in this study came from a larger database, the National Early Childhood Assessment Project (NECAP). The purpose of the NECAP is to examine the development of language and social skills of young children (6 months to 4 years of age) who are DHH throughout the United States. Specifically, the NECAP attempts to characterize the language strengths and weaknesses of these children and identify factors that are predictive of more successful language outcomes. Two hundred twelve assessments were available in the NECAP Spanish-speaking database,[2] but only the most recent assessment of each participant was considered for this cross-sectional study, resulting in a sample of 68 children.

Specific eligibility criteria for the children in the study included children (a) with permanent bilateral hearing loss, (b) between 8 and 36 months of age, (c) with no additional disabilities (per parents and interventionists' report), (d) with no diagnosis of auditory neuropathy, and (e) whose primary home language was Spanish (per parents' report), regardless of whether or not sign language was also used. Families whose primary language was English and who also spoke Spanish were not included in the study. Fifteen participants were excluded from the final sample because the degree of hearing loss was not available. The final sample was composed of 53 participants, 29 girls and 24 boys, between 8 and 34 months of age ($M$ = 24, $SD$ = 6.9). Tables 1 and 2 summarize the samples' demographic and hearing loss characteristics.

Six states contributed data to this study, including Arizona, Idaho, Utah, Texas, Indiana, and California. All of the participants were Hispanic/Latino, with the vast majority of Mexican origin. Forty-four children (83%) did not pass the newborn hearing screening, eight (15%) passed, and one was reported unknown. We used audiologic records to determine the children's degree of hearing loss based on their better ear pure-tone average, that is, the average of the hearing thresholds at 500, 1000, and 2000 Hz. The children's age of hearing loss identification ranged from less than 1 month of age to 27 months of age ($M$ = 4.4, $SD$ = 4.8). Age of amplification ranged from 2 to 25 months ($M$ = 7.7, $SD$ = 5.2), and age of enrollment in intervention ranged from 1 to 27 months ($M$ = 7.5, $SD$ = 6.1). Four children did not use any hearing device. Forty percent of the participants met the Early Hearing Detection and Intervention (EHDI) guidelines of hearing screening by 1 month of age, identification by 3 months of age, and enrollment in intervention by 6 months of age (American Academy of Pediatrics, 2007).

The majority of the families (92%) reported using primarily spoken language with their children (with 37% reporting very occasional use of sign language). Only 8% reported trying to sign as much as possible in conjunction with spoken language. In all cases, the predominant language spoken at home was Spanish, and for those who used signs, these were drawn from ASL and were used to support spoken Spanish following a Spanish syntactic structure. In addition, 38% of the families reported using some spoken English at home; however, in all cases, it was used less than 50% of the time.

#### Services

All children and families received early intervention services in their home from a teacher of the deaf or a

**Table 1.** Demographic characteristics.

| Characteristics | *n* | % |
|---|---|---|
| Maternal education | | |
| Less than high school | 24 | 45 |
| High school or higher | 25 | 47 |
| High school/vocational | 20 | 38 |
| Bachelor or higher | 5 | 9 |
| Missing data | 4 | 8 |
| Deaf adult in the home | 3 | 6 |
| Gender | | |
| Boys | 24 | 45 |
| Girls | 29 | 55 |
| Mode of communication | | |
| Spoken language only | 29 | 55 |
| Spoken language with occasional sign | 20 | 37 |
| Speech and sign | 4 | 8 |
| English spoken at home | 20 | 38 |

[2]This project was approved by the Arizona State University Institutional Review Board for secondary data analysis.

**Table 2.** Hearing loss characteristics.

| Characteristics | *n* | % |
|---|---|---|
| Onset of the hearing loss | | |
| Birth | 47 | 88 |
| Acquired | 4 | 8 |
| Unknown | 2 | 4 |
| Degree of hearing loss | | |
| Mild to moderate | 29 | 55 |
| Mild (26–40 dB HL) | 13 | 25 |
| Moderate (41–55 dB HL) | 16 | 30 |
| Moderately severe to profound | 24 | 45 |
| Moderately severe (56–70 dB HL) | 8 | 15 |
| Severe (71–90 dB HL) | 10 | 19 |
| Profound (> 91 dB HL) | 6 | 11 |
| Type of amplification | | |
| None | 4 | 8 |
| Hearing aids | 34 | 63 |
| Cochlear implants | 10 | 19 |
| Bone conduction aids | 3 | 6 |
| Hearing aid and cochlear implant | 2 | 4 |
| Amplification use (per day) | | |
| Less than 6 hr | 7 | 13 |
| < 3 hr | 2 | 4 |
| 3–5 hr | 5 | 9 |
| More than 5 hr | 42 | 79 |
| 6–10 hr | 23 | 43 |
| > 10 hr | 19 | 36 |
| No aid | 4 | 8 |
| Functional hearing | | |
| Normal function | 19 | 36 |
| Below normal function | 33 | 62 |
| Mildly limited | 17 | 32 |
| Severely limited | 12 | 22 |
| No functional hearing | 4 | 8 |
| Missing data | 1 | 2 |

speech-language pathologist. Part C of the Individuals With Disabilities Education Act (2004) regulates early intervention programs. The Individuals With Disabilities Education Act dictates that services for children from birth to 3 years of age are to be family-centered and provided in natural environments to meet the individual needs of the child. Intervention goals and session frequency are to be determined based on the needs of each family. The children received, on average, 148 min per month of early intervention at home (range: 45–240 min). Some children received additional intervention services either in their home or at a clinic. Families were encouraged to use their home language during the intervention sessions and in daily life. Whenever possible, they were assigned an interventionist who spoke Spanish. When this was not possible, a Spanish-speaking interpreter accompanied the interventionist to each session. Table 3 shows the variety of services and minutes per month the children and families received.

## *Measures*

### Initial and Follow-Up Demographic Forms

Primary caregivers along with their interventionists completed an initial demographic form when first assessed and a follow-up form every 6 months along with the other assessments. The initial form contained information, such as the child's gender, ethnicity and race, language(s) spoken at home, communication mode used, amplification received, presence of additional disabilities, parent educational level, and the type and amount of intervention received. The follow-up forms asked for changes in communication mode, amplification, presence of additional disabilities, and type and amount of intervention received.

### Functional Hearing Abilities Rating

Caregivers were asked to categorize the child's functional hearing ability when using amplification. Ratings were 1 = "*functions normally*: Child has negligible difficulty receiving auditory information," 2 = "*mildly limited*: Child needs frequent spoken repetitions, occasional visual, and/or tactile communication support," 3 = "*severely limited*: Child realizes some benefit from auditory communication, although unable to function adequately without visual or tactile communication," and 4 = "*no functional hearing*: Child receives no benefit from spoken communication." Previous studies have shown that parental reports of functional hearing abilities correlate with hearing thresholds and should be used in addition to audiologic testing (e.g., Ben-Itzhak, Greenstein, & Kishon-Rabin, 2014).

### IDHC

The IDHC (Jackson-Maldonado et al., 2003) is a caregiver report instrument that assesses children's communication and vocabulary skills. The inventories list a variety of early-developing words arranged in different semantic categories. It was developed for and normed on hearing children from Spanish-speaking families in Mexico. To reduce the impact of dialectical differences on a child's score, researchers at the University of Colorado–Boulder convened a team of four native Spanish speakers, each from a different region or country (Puerto Rico, two regions of Mexico, and Venezuela), who met over a 3-month period to review and discuss each vocabulary item on the test. Alternative forms of specific words were added next to a given vocabulary item if a reviewer felt families from her country would be unfamiliar with (or would not use) a particular word. The child's primary caregiver was instructed to mark all the words that his or her child spontaneously produced in spoken language (Spanish or English) and/or sign language.

Several investigators have used the MacArthur inventories with bilingual children (Spanish–English) as well as English-speaking children with hearing loss. The validity of both the IDHC and the MacArthur–Bates Communicative Development Inventories (CDI; Fenson et al., 2007) has been demonstrated with hearing bilingual populations, with children from low-SES families, and with children older than the norming sample who have delayed language skills. Correlations ranged from .35 to .79 between the MacArthur inventories and language samples of vocabulary as well as between the MacArthur inventories and direct productive and receptive vocabulary measures in bilingual children (Mancilla-Martínez, Gámez, Vagh, & Lesaux, 2016; Marchman & Martínez-Sussman, 2002). In addition, although the IDHC has not been used in previous research with children who

**Table 3.** Amount of service per month.

| Type of service | *n* | % | Range of sessions per month | Range of minutes per session | Mean minutes per month |
|---|---|---|---|---|---|
| Early intervention at home | 53 | 100 | 1–4 | 45–60 | 148.5 |
| Early intervention out of home | 3 | 6 | 4 | 45–60 | 220.0 |
| Speech at home | 12 | 23 | 1–4 | 30–60 | 137.5 |
| Speech out of home | 15 | 28 | 1–8 | 30–60 | 91.73 |
| Toddler group | 8 | 15 | 1–12 | 150–180 | 813.75 |
| Preschool (mainstream) | 1 | 2 | 22 | 360 | 7920.0 |
| Occupational therapy | 5 | 9 | | | |
| Physical therapy | 5 | 9 | | | |
| Deaf mentor | 5 | 9 | | | |
| Sign language classes (parents) | 2 | 4 | | | |

*Note*. Percentages add to more than 100 because some children received more than one service.

are DHH, the CDI has been shown to be a valid measure of vocabulary outcomes in English-speaking children with CIs and children who were in the early stages of language development, even if they were older than the norming sample. Correlations ranged from .43 to .93 between the CDI and direct productive and receptive vocabulary measures of children with CIs (Nicholas & Geers, 2008; Thal, DesJardin, & Eisenberg, 2007).

In keeping with the administration instructions in the test manual for populations with known language delays, the level of the inventory administered was determined based on the interventionists and/or caregivers' estimate of the child's productive vocabulary size rather than the child's chronological age. Children whose vocabulary size was estimated to be between 40 and 50 words or less received Palabras y Gestos (Words and Gestures), Inventory I; those with more than 50 words were administered Palabras y Enunciados (Words and Sentences), Inventory II.

The inventories were adapted so that for every vocabulary item, instead of having one box where caregivers could mark if the child produced the word, the inventories included two boxes, one for spoken language ("says") and one for sign language ("signs"). The "says and signs," "signs only," and "says only" were added together to obtain conceptual vocabulary raw scores. Raw scores were converted to vocabulary age scores using the procedure described in the test manual. Specifically, the median (50th percentile) was used as a reference level for the expected vocabulary size at a given chronological age. Each participant's vocabulary score was compared to the median scores across the age range. An age score was assigned based on which chronological age's median was closest to the participant's score. For example, a boy who scored seven words would be assigned a vocabulary age of 14 months by looking at the 50th percentile in the IDHC manual.

Expressive vocabulary quotients were calculated using the following formula: vocabulary age/chronological age × 100. Thus, a vocabulary quotient of 100 indicated that a child's vocabulary age was commensurate with his or her chronological age. Quotients below 100 indicated a vocabulary score below age level, and quotients above 100 indicated that the child's vocabulary score was higher than the median of a typical hearing child of the same age. According to the IDHC manual (Jackson-Maldonado et al., 2003), the use of vocabulary quotients instead of percentiles is recommended when assessing children who are older than the norming sample and present language delay.

### *Procedure*

Assessments were delivered to and collected from families by their early interventionists who reviewed the inventories for completeness and accuracy. Assessments were then sent to the University of Colorado–Boulder NECAP staff for scoring. All participating families signed informed consent forms.

## Results

The mean vocabulary quotient for the 53 children in the sample was 77.1 ($SD$ = 26.1). Table 4 shows the vocabulary quotient means and standard deviations by degree of hearing loss, age of intervention, and functional hearing rating. Of the 46 children who had at least one word in their productive vocabulary, 37% produced all of their words in spoken language only and 11% used only sign language to communicate. Of the 52% who used a combination of spoken and signed vocabulary, the proportion of words in each modality varied across the participants.

**Table 4.** Mean vocabulary quotients and standard deviations (MacArthur Inventario del Desarrollo de Habilidades Comunicativas) by group.

| | *M* | *SD* | *n* |
|---|---|---|---|
| Degree of hearing loss | | | |
| Mild to moderate | 88.8 | 22.7 | 29 |
| Moderately severe to profound | 62.9 | 23.1 | 24 |
| Functional hearing | | | |
| Normal function | 92.7 | 18.4 | 19 |
| Below normal function | 68.4 | 25.9 | 34 |
| Age of intervention | | | |
| Early intervention (by 6 months) | 84.3 | 24.8 | 27 |
| Late intervention (after 6 months) | 69.5 | 21.5 | 26 |

In order to explore the different predictors of vocabulary quotients, we first grouped the independent variables into three categories: demographic, hearing loss related, and intervention. Demographic variables included chronological age, gender, and maternal education. Variables related to the hearing loss included degree of hearing loss, functional hearing ability ratings, and amount of time per day using hearing devices. Intervention variables included age of hearing loss identification, age of amplification, and age of enrollment in early intervention. Chronological age and age of hearing loss identification, amplification, and enrollment in early intervention were continuous variables measured in months. The remaining independent variables were collected as categorical variables, and we categorized them as follows: gender (0 = *boy,* 1 = *girl*), maternal education (0 = *less than a high school degree,* 1 = *high school degree or higher*), degree of hearing loss (0 = *mild to moderate,* 1 = *moderately severe to profound*), functional hearing ability ratings (0 = *below normal function,* 1 = *normal function*), and time using hearing devices (0 = *5 hr or less per day,* 1 = *6 hr or more per day*).

## *Relationships Between Vocabulary and the Independent Variables*

Table 5 shows the correlations between the demographic variables, variables related to hearing loss, intervention variables, and vocabulary quotients measured by the IDHC. The correlations between continuous and categorical variables were computed using polyserial correlations. The correlations between two categorical variables were computed using polychoric correlations. Correlations between continuous variables were computed using Pearson correlations. The significance level was set at .001 following the Bonferroni method.

### Demographic Variables

The only demographic variable significantly correlated with vocabulary quotients was chronological age, $r(53) = -.62$, $p < .001$. This correlation suggests that younger children show higher vocabulary quotients than older children. Figure 1 depicts the systematic decline in vocabulary quotients with increasing chronological age. Gender, $r(53) = .10$, $p > .001$, and maternal education, $r(53) = .13$, $p > .001$, were not significantly correlated with vocabulary quotients.

### Variables Related to Hearing Loss

Degree of hearing loss and vocabulary quotients showed a significant moderate correlation, $r(53) = -.55$, $p < .001$, suggesting that the greater the degree of hearing loss, the lower the vocabulary quotients. In addition, functional hearing ability ratings were significantly correlated with vocabulary quotients, $r(53) = .50$, $p < .001$, indicating that children whose parents rate them as having no difficulty receiving auditory information show higher vocabulary quotients than those who report minimal difficulty to no benefit from amplification. Degree of hearing loss and functional hearing ability ratings were strongly correlated with each other, $r(53) = -.77$, $p < .001$. This negative correlation suggests that, as hearing loss increases, functional hearing ability ratings decrease. The amount of time per day using HAs and/or CIs was not correlated with vocabulary quotients, $r(49) = -.09$, $p > .001$.

### Intervention Variables

The age of hearing loss identification, $r(53) = -.21$, $p > .001$, and amplification, $r(49) = -.27$, $p > .001$, were not significantly correlated with vocabulary quotients. Age of enrollment in early intervention, $r(51) = -.34$, $p < .001$, was significantly and negatively correlated with vocabulary quotients. This correlation suggests that the earlier the intervention, the higher the vocabulary quotients. To explore the impact of age of intervention further, children were divided into early (by 6 months) and late (after 6 months) intervention groups according to the EHDI guidelines (American Academy of Pediatrics, 2007). An independent-samples two-tailed $t$ test revealed that children who receive intervention early show significantly higher vocabulary

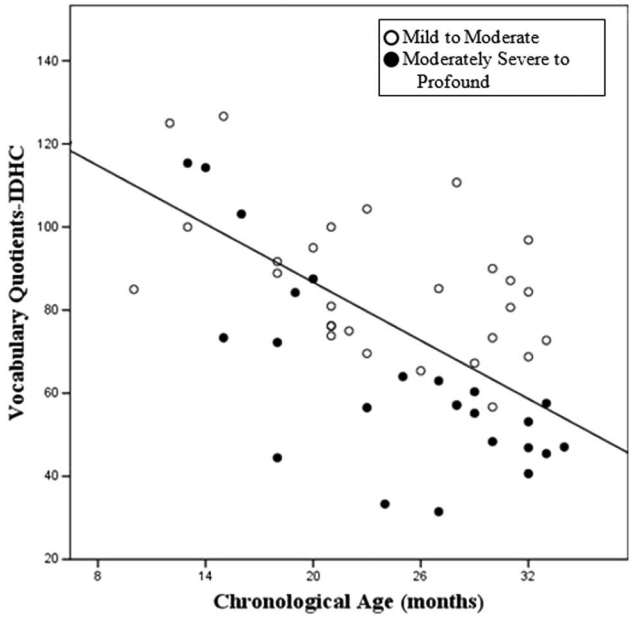
**Table 5.** Correlation matrix of independent variables and vocabulary quotients considered for regression models.

| | | Demographic variables | | | Variables related to the HL | | | Intervention variables | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | *n* | Chronological age | Gender | Maternal education | Degree of HL | Functional hearing | Time using HAs/CIs | Age of identification | Age of amplification | Age of intervention |
| Vocabulary quotients | 53 | –.625* | .108 | .132 | –.554* | .506* | –.097 | –.214 | –.275 | –.345* |
| Chronological age | 53 | | –.062 | –.142 | .142 | –.009 | .194 | .176 | .341* | .320* |
| Gender | 53 | | | –.293 | .104 | .329 | –.032 | .419 | .149 | .273 |
| Maternal education | 53 | | | | –.284 | .173 | –.089 | –.163 | –.047 | –.040 |
| Degree of HL | 53 | | | | | –.776* | .031 | .172 | –.002 | .160 |
| Functional hearing | 53 | | | | | | –.031 | –.203 | .003 | –.104 |
| Time using HAs/CIs | 49 | | | | | | | –.309 | –.162 | –.149 |
| Age of identification | 53 | | | | | | | | .743* | .693* |
| Age of amplification | 49 | | | | | | | | | .839* |
| Age of intervention | 51 | | | | | | | | | |

*Note.* HL = hearing loss; HAs = hearing aids; CIs = cochlear implants.

*$p < .001$ after Bonferroni adjustment (.05/45 = .001).

**Figure 1.** Relationship between chronological age and vocabulary quotients by degree of hearing loss.




quotients than those who receive intervention after 6 months of age, $t(51) = 2.132$, $p = .038$, $d = 0.58$ (see Table 4 for means and standard deviations).

### *Regression Analyses*

We used a hierarchical multiple regression analysis to identify the independent variables that best predicted expressive vocabulary quotients from the IDHC. Gender, maternal education, and the amount of time per day using hearing devices were initially included in the model to confirm that they were not significantly related to vocabulary quotients when controlling for all other variables. These variables remained nonsignificant and were removed from the final model.

Table 6 summarizes the regression models, coefficients, and their unique contribution. In Model 1, we tested the contribution of the demographic variable (chronological age). In Model 2, we tested whether variables related to the hearing loss (degree of hearing loss and functional hearing ability ratings) and an intervention variable (age of intervention) explained additional variance in the vocabulary quotients over and above the demographic variable (chronological age). Finally, in Model 3, we tested all possible interactions among the predictor variables included in Models 1 and 2. Two subjects were dropped because the age of intervention was missing, reducing the sample to 51 subjects in Models 2 and 3.

In Model 1, chronological age accounted for 35.8% of the variance in children's vocabulary quotients, $F(1, 49) = 28.89$, $p < .001$. In Model 2, chronological age was introduced at Step 1 and degree of hearing loss, functional hearing ability ratings, and age of intervention were introduced at Step 2 to examine the unique variance contributed by these variables over and above chronological age. Model 2 accounted for 58.4% of the variance in children's vocabulary quotients, $F(4, 46) = 18.53$, $p < .001$. $R^2$ change (.246) was significant at Step 2, $F(3, 46) = 9.85$, $p < .001$, indicating a significant unique contribution of degree of hearing loss, functional hearing ability ratings, and age of intervention over and above chronological age. Finally, Model 3 explored all possible interactions among the predictors included in Model 2. The only significant interaction was between chronological age and age of intervention (see Figure 2), and it contributed an extra 3.6% to the variance in children's vocabulary quotients, $F(1, 45) = 4.68$, $p < .05$. The interaction indicated that the positive effect of early age of intervention on vocabulary quotients decreased as chronological age increased. The final Model 3 that included the predictors and the interaction accounted for 61.5% of the variance in children's vocabulary quotients, $F(5, 45) = 16.94$, $p < .001$.

## Discussion

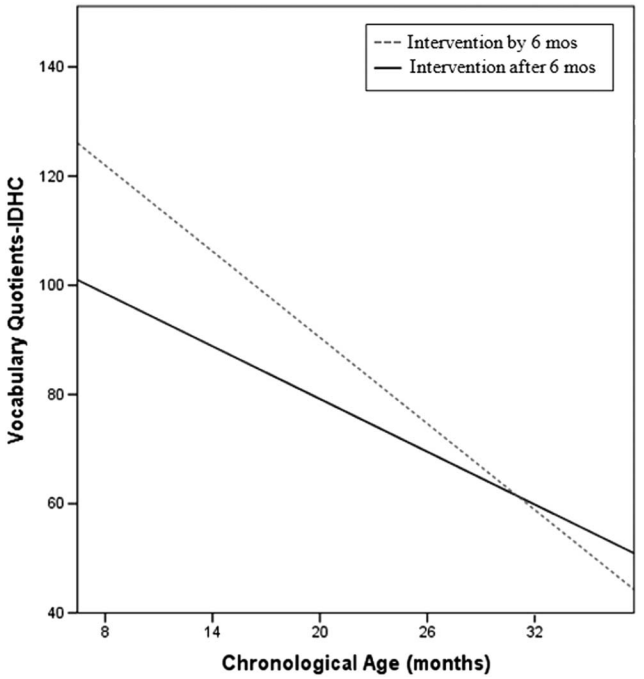
The purpose of this study was to identify predictors of expressive vocabulary quotients in Spanish-speaking children who are DHH. Results indicated that chronological age, degree of hearing loss, functional hearing ability ratings, age of intervention, and the interaction between chronological

**Table 6.** Summary of the hierarchical regression analysis for variables predicting vocabulary quotients ($N = 51$).

| | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | ***B*** | ***SE B*** | **β** | ***B*** | ***SE B*** | **β** | ***B*** | ***SE B*** | **β** |
| Chronological age | –2.15 | 0.42 | –.60** | –2.15 | 0.34 | –.58** | –3.01 | 0.51 | –.81** |
| Degree of HL | | | | –14.27 | 5.53 | –.27* | –11.40 | 5.48 | –.22* |
| Functional hearing | | | | 15.43 | 5.63 | .29** | 16.79 | 5.45 | .31** |
| Age of intervention | | | | –0.14 | 0.39 | –.03 | –3.84 | 1.79 | –.91* |
| CA × AI | | | | | | | 0.14 | 0.06 | .95* |
| Adjusted $R^2$ | | 0.35 | | | 0.58 | | | 0.61 | |
| $F$ for change in $R^2$ | | 28.89** | | | 9.85** | | | 4.68* | |

*Note.* HL = hearing loss; CA = chronological age; AI = age of intervention.
*$p < .05$. **$p < .01$.

**Figure 2.** Vocabulary quotients as a function of chronological age and age of intervention.



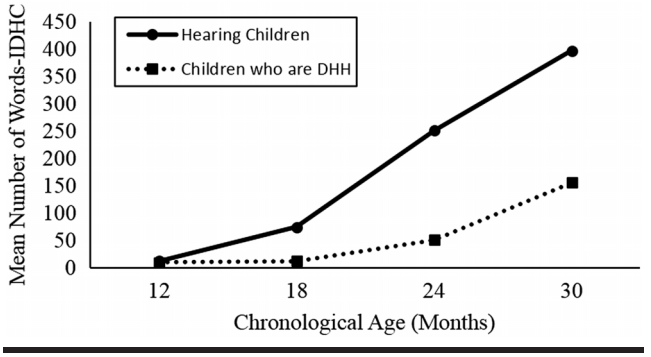

age and age of intervention significantly predicted vocabulary quotients, accounting for 61.5% of the variance. These predictors are consistent with previous research with English-speaking children that found higher language quotients to be related to younger children (Vohr et al., 2011; Yoshinaga-Itano et al., 2017), lesser degrees of hearing loss (e.g., Ching et al., 2010, 2013), and earlier intervention (e.g., Holzinger et al., 2011; Lin et al., 2011; Quittner et al., 2016; Vohr et al., 2008, 2011; Yoshinaga-Itano et al., 2017).

Results indicate that children who received intervention early (by 6 months of age) had significantly higher vocabulary quotients than children who received intervention late (after 6 months of age); however, the protective effect of early age of intervention in this sample was not sufficient to maintain children's vocabulary quotients at the level expected by Spanish-speaking hearing peers. As both age of intervention and chronological age increased, vocabulary quotients decreased. This drop in vocabulary quotients for older children indicates that the gap between language age and chronological age is wider for older children than younger children. This also has been reported in monolingual English-speaking children with hearing loss (Mayne, Yoshinaga-Itano, Sedey, & Carey, 1999; Vohr et al., 2011; Yoshinaga-Itano et al., 2010, 2017). Yoshinaga-Itano et al. (2017) reported that vocabulary quotients from the CDI in 448 children who were DHH aged 8–39 months were higher for children who met the EHDI guidelines; however, vocabulary quotients decreased by chronological age. Similarly, children in the current study showed an observable decline in vocabulary quotients after 18 months of age (see Figure 1), suggesting that children struggle to keep up with the exponential growth in vocabulary observed in hearing peers after this age.

Spanish-speaking children with normal hearing show a rapid increase in expressive vocabulary skills beginning at 18 months of age. Specifically, children produce about 50–100 words by 18 months of age, increasing to 250 words by 24 months of age and 400 words by 30 months of age (Jackson-Maldonado et al., 2003). Vocabulary also increases in abstractness; first words refer to objects or actions tied to the context (e.g., "water" or "open"), whereas words expected by 24–30 months of age include more abstract concepts (e.g., "scary" or "tomorrow"). Even when using hearing devices, children with hearing loss often have difficulties in situations that involve distance and background noise, which can affect vocabulary learning (e.g., Pittman, 2011). The rapid increase expected in the number and variety of words and the difficulties children with hearing loss face with incidental learning may explain why children with hearing loss did not show vocabulary quotients equivalent to those expected by hearing peers. Older children demonstrated increases in vocabulary, but the mean number of words by age was considerably below the mean number of words observed in hearing peers (see Figure 3).

The delay in vocabulary was especially pronounced between 30 and 34 months of age, with the majority of the children in this study demonstrating vocabulary quotients below 100, indicating that they score below chronological age expectations. This vocabulary delay at preschool age has the potential to interfere with the development of language and literacy skills and subsequent academic achievement (Proctor et al., 2005, 2012). Whenever possible, education and speech and language intervention should support language development in all relevant language(s) for these children, given the socioemotional, cultural, academic, and self-esteem benefits of maintaining the home language and the benefits of having communication at home (Kohnert et al., 2005). In addition, a large vocabulary in the home language could facilitate English reading and academic

**Figure 3.** Mean number of expressive words by chronological age. Means for hearing children are drawn from the test norms in the MacArthur Inventario del Desarrollo de Habilidades Comunicativas (IDHC) manual (Jackson-Maldonado et al., 2003).



skills (e.g., Kieffer, 2012; Proctor, August, Carlo, & Snow, 2006).

Contrary to our hypothesis, maternal education (categorized as less than a high school diploma vs. a high school degree or higher) was not a significant predictor of vocabulary quotients. This is in contrast to many previous investigations with English-speaking families (e.g., Ching et al., 2013; Quittner et al., 2016; Yoshinaga-Itano et al., 2010). For example, large differences in language ability have been noted in children who are DHH from English-speaking homes when comparing mothers who have less than a high school diploma to those with a high school diploma or higher (Sedey & Yoshinaga-Itano, 2012). These differences were not apparent in the present sample, indicating that there may be fundamental differences between English-speaking and Spanish-speaking mothers in the United States who did not complete high school. It is also possible that defining the two educational groups differently would result in a positive association of mother's level of education and child vocabulary scores. Specifically, children of mothers who had completed a bachelor's degree, on average, had vocabulary quotients that were 11 points higher than children whose mothers had less than a bachelor's degree. This could not be examined statistically as only five mothers were in the group with a bachelor's degree or higher. Future studies may include children with higher maternal educational levels to evaluate this relationship.

### *Limitations and Future Directions*

Several factors need to be kept in mind when interpreting the results of this study. First, language was assessed in only one domain (expressive vocabulary). Future research is needed to explore if the factors predictive of expressive vocabulary development also impact additional areas of language, such as syntax, pragmatics, and comprehension. A second important consideration is that the vocabulary of the participants was assessed using an instrument that was normed on a monolingual Spanish-speaking population living in Mexico. Because data from a hearing comparison group were not collected, children were compared to the IDHC normative sample. Like the normative sample, some of the participants used and were exposed to only spoken Spanish; however, others lived in homes in which spoken English and/or sign language was used to some extent. Although this is representative of the varied language environments of children who are DHH living in the United States and children were given credit for words regardless of the language or modality used, we would not necessarily expect the children's vocabulary growth to follow the same course or rate of development as the normative sample. In addition, the participants included children with language delay who were older than the norming sample. According to the IDHC manual (Jackson-Maldonado et al., 2003), when children show language delay, are exposed to a second language (e.g., English and/or sign language for some of the participants), and come from low-SES families, we should use language quotients and apply norms carefully.

Taking into account both spoken and signed words when calculating the conceptual vocabulary scores helps compensate for some of the biases that might be present for children exposed to multiple languages and/or communication modalities To explore the issue of children using multiple languages, we examined both total scoring (assigning 2 points for a word produced in both sign and spoken languages) and conceptual scoring (assigning 1 point for a word regardless of modality), and only minimal differences were seen using the two different scoring methods. This was because the majority of the children were reported to have either spoken words or signs, but not both, for the same vocabulary item. Previous research has shown that children with small oral vocabularies have very few translation equivalents (e.g., Bosch & Ramon-Casas, 2014). Future research should assess English and Spanish separately to offer detailed information about all the languages spoken by children who are DHH in the United States. In addition, future research should validate the use of the IDHC to assess vocabulary across languages in these children.

There were some limitations in the measures and predictors included in the study. First, measuring functional hearing ability using a rating scale from 1 to 4 was simplistic. In future studies, we need to consider more refined tools that include constructs of different auditory skills. Second, disability status was determined by parent and/or interventionist report. It is possible that some children in the study had an additional disability that was not yet apparent to their parent and/or interventionist. Third, communication mode was not included in the analyses as a predictor due to limitations in its measurement. Information about the caregivers' proficiency in sign language, as well as the use of language samples to assess language performance, is necessary in order to consider communication mode as a predictor of vocabulary outcomes. Moreover, examining the language used during the intervention and assessing the quality and quantity of each language used in the home may help explore the role of language input on vocabulary development.

One unexpected finding was that the amount of time per day using HAs and/or CIs was not correlated with vocabulary quotients. This is may be because, as children got older, they wore the hearing devices for longer periods, but older children showed a decrease in vocabulary quotients. The relationship between amount of device use and language ability needs to be studied further in future studies controlling for child age.

Future research should also include variables that address the quality of the intervention. It is critical that we identify intervention strategies that maximize children's vocabulary acquisition in order to decrease the gap observed between children who are DHH and children with normal hearing. Measures such as family involvement and maternal sensitivity should be included in future studies with Spanish-speaking families of children who are DHH considering the impact that culture and language may have in the intervention. Previous research has shown family involvement in the intervention to be a strong predictor of vocabulary

skills in English-speaking children with hearing loss (Calderon, 2000; DesJardin, 2006; DesJardin & Eisenberg, 2007; Moeller, 2000; Watkin et al., 2007). Moreover, future research may examine how intervention is provided to Spanish-speaking families. Specifically of interest would be a comparison of intervention effectiveness between families receiving intervention services via an interpreter versus those who receive services directly from a Spanish-speaking provider. We may also explore the cognitive and language stimulation strategies used in the interventionists and caregivers' interactions with children who are DHH to identify the most effective strategies and optimize the intervention, as has been suggested for English-speaking children (Cruz, Quittner, Marker, & DesJardin, 2013; Quittner et al., 2013, 2016).

## Conclusions

Chronological age, degree of hearing loss, functional hearing ability ratings, age of intervention, and the interaction between chronological age and age of intervention accounted for 61.5% of the variance in children's vocabulary quotients. Intervention by 6 months of age resulted in significantly higher vocabulary outcomes than intervention started after this age. However, even children who received intervention early showed vocabulary outcomes below hearing peers, especially older children and those with greater degrees of hearing loss. This delay in vocabulary outcomes has the potential to interfere with future reading and academic outcomes. Questions remain regarding how other predictors related to the intervention, including family involvement and the language stimulation strategies used, can positively affect the vocabulary outcomes of these children.

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