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## Dimensions of Deaf/Hard-of Hearing and Hearing Adolescents' Health Literacy and Health Knowledge

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### Abstract

Deaf and hard-of-hearing (D/HH) adults have lower health literacy compared to hearing adults but it is unclear if this disparity also occurs in adolescence. We used the Health Literacy Skills Instrument-Short Form (HLSI-SF), Short Form of the Test of Functional Health Literacy (S-TOFHLA), Comprehensive Heart Disease Knowledge Questionnaire (CHDKQ) and newly constructed interactive and critical health literacy survey items to quantify D/HH and hearing adolescents' health literacy. We adapted and translated survey materials into sign language and spoken English to reduce testing bias due to variable English language skills. Participants were 187 D/HH and 94 hearing college-bound high school students. Adjusting for age, gender, race/ethnicity, school grade, and SES, D/HH adolescents demonstrated weaker general and functional health literacy and cardiovascular health knowledge than hearing adolescents on the HLSI, S-TOFHLA, and CHDKQ (all  $p < .0001$ ). Standard health literacy or knowledge scores were associated with several interactive and critical health literacy skills (all  $p < .05$ ). D/HH adolescents who reported greater hearing-culture identity, having hearing aids, experiencing better hearing with assistive devices, having good quality of communication with parents, and attending hearing schools at least half of the time had higher functional health literacy (all  $p < .025$ ). Those who reported English as their best language and attending hearing schools at least half the time had higher cardiovascular health knowledge scores (all  $p < .03$ ). Results suggest that interventions to improve D/HH adolescents' health literacy should target their health-related conversations with their families, access to printed health information, and access to health information from other people, especially health care providers and educators.

### Keywords

adolescent health literacy; functional, interactive, and critical health literacy; cardiovascular health knowledge; deaf health literacy

### Introduction

Growing evidence indicates that D/HH people have substantial health knowledge and health literacy weaknesses. Of 203 D/HH adults in Chicago, 40% could not name any heart attack

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<sup>1</sup>We use the abbreviation "D/HH" here to refer to individuals with childhood onset of deafness who typically, but not always, use American Sign Language or Signed English as their primary language

symptoms and over 60% could not name any stroke symptoms (Margellos-Anast, Estarziau, & Kaufman, 2006). McKee, Paasche-Orlow, et al. (2015) reported that 48% of 166 Deaf participants given a sign language version of the Newest Vital Sign (ASL-NVS) had inadequate health literacy, a nearly 7 fold difference compared to 239 hearing participants.

These disparities in health literacy may be relevant to disparities in the health outcomes of D/HH people (Moreland, Atcherson, Zazove, & McKee, 2015; McKee & Paasche-Orlow, 2012; McKee, Schlehofer, et al., 2011; Pollard & Barnett, 2009). Deaf or Hard-of-Hearing (D/HH) adults report more health problems, including obesity, intimate partner violence, and suicidal behaviors than the general adult population (Barnett et al., 2011). They also utilize health care differently (McKee, Moreland, Atcherson, & Zazove, 2015; McKee, Barnett, Block, & Pearson, 2011). For example, D/HH individuals are more likely to use the emergency department over the prior 36 months than hearing individuals for complex cultural and experiential reasons (McKee, Winters, Sen, Zazove, & Fiscella, 2015).

Recent work supports the hypothesis that D/HH people's health literacy deficits are present in adolescence. Smith, Kushalnagar, and Hauser (2015) found that D/HH adolescents have weak cardiovascular health literacy, similar to D/HH adults, lacking knowledge about basic cardiovascular pathophysiology, their family cardiovascular health history, and important common medical terms like "cholesterol". To date, no studies have systematically quantified D/HH adolescents' health literacy and general knowledge.

Because health literacy is a multidimensional construct, it is a challenge to measure (Nutbeam, 2008), especially in populations whose best language is typically not English (McKee & Paasche-Orlow, 2012; Sentell & Braun, 2012). Parker, Baker, Williams, & Nurss (1995) define functional health literacy as "being able to apply literacy skills to health related materials such as prescriptions, appointment cards, medicine labels, and directions for home health care". An individual's ability to read and understand printed English and numerical health information has been the essential competency underlying functional health literacy measurement in the US. Traditional assessments include the Rapid Estimate of Adult Literacy in Medicine (Davis et al., 1991), the Short Form of the Test of Functional Health Literacy (Baker, Williams, Parker, Gazmararian, & Nurss, 1999), Newest Vital Sign (Weiss et al., 2005), and Medical Term Recognition Test (Rawson et al., 2010). These measures often provide meaningful information about health literacy and health outcomes (Marrie, Salter, Tyry, Fox, & Cutter, 2014; Sharif & Blank, 2010), but represent health literacy constructs biased toward printed and spoken literacy (Chinn & McCarthy, 2012; Berkman, Davis, & McCormack, 2010; Nutbeam, 2009; Nutbeam, 2008).

A broader health literacy construct encompassing dimensions such as interactive and critical health literacy skills and experiences (Nutbeam, 2009) and health knowledge (Al Sayah, Majumdar, Egede, & Johnson, 2015), in addition to functional health literacy, provides more meaningful information (Haun, Valerio, McCormack, Sorensen, & Paasche-Orlow, 2014), especially about people with limited English proficiency (McKee & Paasche-Orlow, 2012). Interactive health literacy involves the use of advanced social, cognitive, and communication skills to interact with and obtain health knowledge from others, such as parents, teachers, and health care providers and adapt to changing circumstances (Nutbeam, 2008). Critical

health literacy involves judgment and evaluation skills necessary to analyze health information and better control life circumstances to be healthy (Nutbeam, 2008). Health literacy instruments that capture some interactive and critical literacy skills include the e-Health Literacy Scale (Norman & Skinner, 2006); Communicative and Critical Health Literacy Measure (Ishikawa, Nomura, Sato, & Yano, 2008); Media Health Literacy (Levin-Zamir, Lemish, & Gofin, 2011); and All Aspects of Health Literacy Scale (AAHLS; Chinn & McCarthy, 2012). Other tools capture a broader construct of “overall health literacy” that incorporates elements of interactive and critical health literacy, e.g., Health Literacy Skills Instrument (McCormack et al., 2010). Furthermore, several health literacy measures have been developed for adolescents including Adolescent Health Literacy (Wu et al, 2010); Adolescent Media Health literacy (Levin-Zamir, Lemish, & Gofin, 2011); e-Health Literacy Scale (Norman & Skinner., 2006), and REALM-Teen (Davis, et al., 2006). However, none of these measures has been adapted for D/HH adolescents.

The complexity of the health literacy construct complicates health literacy measurement in D/HH people. Functional health literacy instruments are intended to measure an individual’s ability to understand and use conventional printed health materials and may therefore provide some useful information about the ability of D/HH individuals with limited English language skills to access conventional English-dependent health information in the real world. However, functional literacy in people with limited English proficiency is discipline-specific (Fang & Schleppegrell, 2010), and, as a result, D/HH individuals’ performance on functional health literacy measures may not accurately reflect their true functional health literacy in specific health contexts.

Furthermore, interactive and critical health literacy constructs extend beyond English-dependent access because they do not require English language and reading skills per se, but rather access to effective communication within the health care system and information environment. Nevertheless, interactive and critical health literacy assessment instruments in the US typically do rely on spoken or printed English language skills and cultural-specific fund-of-information that are not appropriate for the D/HH population (Pollard & Barnett, 2009). Therefore, using such English-based instruments can introduce construct-irrelevant linguistic and cultural testing biases into items meant to assess health literacy skills that, in principle, do not fundamentally require English language skills.

Appropriate linguistic and cultural translation and adaptation of measures of health literacy and knowledge dimensions other than English-based functional health literacy per se are necessary to ensure construct-relevant assessment. Such measures will provide more accurate information to guide future research and interventions to improve D/HH adolescents’ health literacy and ultimately to reduce and eliminate D/HH people’s health disparities.

### **Study Purpose and Aims**

Previous health literacy studies of D/HH people (e.g., McKee, Paasche-Orlow, et al., 2015; McKee & Paasche-Orlow, 2012; McKee, Schlehofer, et al., 2011; Pollard & Barnett, 2009; Margellos-Anast, Estarziou, & Kaufman, 2006) have not adequately controlled for the potential confounding influence of English print literacy on health literacy measures based

on underlying constructs that do not essentially depend on English language skill. Construct-irrelevant sources of variance in such measures may specifically include, for example, the use of English for administering the test instructions of standard measures or the use of English survey questions to query individuals with limited English about their actual access to health care or their health knowledge. Therefore, our first aim was to quantitatively test whether evidence of disparities in D/HH and hearing adolescents' health literacy and health knowledge remain on a set of gold standard health literacy measures after translating and adapting those measures for both populations to eliminate any test-instrument dependence on English that is irrelevant to health literacy measurement.

Since various common demographic factors such as age, gender, race/ethnicity, grade-level, and socioeconomic status may be associated with group differences in health literacy and health knowledge (Nolke, Mensing, Kramer, & Hornberg, 2015; Freedman, Kouri, West, & Keating, 2015; Green & Cavanaugh, 2015), we controlled these factors in comparisons of D/HH and hearing adolescents. Furthermore, we conducted analyses to determine whether D/HH adolescents' health disparities persist on each standard health literacy measure even after controlling for the other standard health literacy measures. These analyses evaluate for evidence of distinct domains of health literacy and health knowledge in D/HH adolescents.

Our second aim was to quantitatively compare D/HH adolescents' versus hearing adolescents' interactive and critical health literacy skills and experiences for the first time. Because other interactive and critical health literacy measures were not suitable for use by D/HH and hearing adolescents, we used qualitative findings from focus groups (Smith et al., 2015) to create several original items to measure their interactive and critical health literacy skills and experiences.

Our third aim was to identify subgroups of D/HH adolescents who might have stronger health literacy than others. This information will help guide future research and specific interventions for those with weaker health literacy.

## Methods

### Participants

D/HH participants were 187 high school students who attended one of two 2013 Explore Your Future summer programs at the National Technical Institute for the Deaf (NTID) at the Rochester Institute of Technology (RIT). Hearing participants were 94 high school students who attended one of several 2014 summer medical career orientation programs at the University of Rochester Medical Center (URMC). D/HH and hearing participants in these programs are "college-bound" students. Program acceptance requires students to demonstrate performance in core academic subjects that strongly suggest they will pass high school graduation exit exams and gain admission to competitive colleges or universities. Program staff carefully evaluated applicants academically. No member of the research study team was involved in screening applicants.

We established relationships with pre-college summer career exploration programs at both institutions to recruit study participants. The survey was presented to campers as part of a

public health workshop designed to inform them about research and health literacy in general. No personal identifying information was collected. Therefore, formal documentation of parental consent was unnecessary. All participants' parents were notified that their child would be invited to voluntarily participate in a health literacy and health knowledge survey. All students could decline survey participation.

Participants had 40 to 55 minutes to complete their survey, depending on class schedules. There was no penalty for skipping questions or not completing the survey within the time limit. The Institutional Review Boards at UPMC and NTID/RIT approved all procedures.

## Measures

**Standard health literacy measures**—We conducted a comprehensive literature review of health literacy measures, assessments, and tools to identify relevant and potentially adaptable measures for D/HH adolescents. We identified 12 candidate health literacy and health knowledge measures. However, some measures were not appropriate for use with deaf adolescents because they required speech, or contained culturally inappropriate content. Three standard health literacy measures were accepted for adaptation for D/HH adolescents to capture different aspects of health literacy and health knowledge.

**General health literacy:** Health Literacy Skills Instrument-Short Form (HLSI-SF; Bann, McCormack, Berkman, & Squiers, 2012). The 10-item HLSI-SF assesses overall health literacy, probing a wide range of skills related to accessing and interpreting health-related information from various sources (e.g., print, charts, maps, brochures, videos, and websites). These skills are necessary to understand and apply health information presented in formats including and beyond printed words and numbers. The HLSI-SF is valid with acceptable internal consistency reliability for group-level comparisons, and is usually completed within ten minutes (Bann et al., 2012).

We intentionally did not translate text within the existing standard materials that the HLSI-SF requires participants to interpret and answer questions about because these materials are intended to represent real-world health-related materials conventionally offered to consumers of health information and health care, including D/HH people. That is, the HLSI contains a functional health literacy component to assess overall health literacy. However, while an individual's ability to interpret these materials is relevant to their overall health literacy, their ability to interpret the specifically formatted language of the test instrument itself is construct-irrelevant. Therefore, we adapted the HLSI-SF by translating the English instructions, questions, answers, and phone-tree menu into American Sign Language (ASL) and Conceptually Accurate Sign English (CASE)<sup>2</sup> and included captions of health-related video narrations to eliminate this source of assessment error. Such multi-lingual adaptations restrict the influence of English knowledge to the construct-relevant functional health literacy component of this measure.

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<sup>2</sup>Conceptually accurate sign English refers to the use of simultaneously communicated conceptually accurate sign choices and ASL features that follow English word order

**Functional health literacy:** Short Form of the Test of Functional Health Literacy (S-TOFHLA; Baker, Williams, Parker, Gazmararian, & Nurss, 1999). The S-TOFHLA is a gold-standard measure of functional health literacy, a 36-item cloze assessment of an individual's ability to read and understand printed health information. Participants choose one of four word options that best continue sentences within two health-related passages. Since functional health literacy by definition depends upon printed text comprehension, we administered the S-TOFHLA without any translation or adaptation. The S-TOFHLA was programmed as an interactive computer application, as has been done in other studies without any significant changes to its psychometric properties (Chesser, Keene-Woods, Wipperman, Wilson, & Dong, 2014).

**Health knowledge:** The Comprehensive Heart Disease Knowledge Questionnaire (CHDKQ; Bergman, Reeve, Moser, Scholl, & Klein, 2011). The CHDKQ is a 30-item test of general cardiovascular knowledge that has good convergent and divergent validity with other cardiovascular and general health literacy measures, respectively, and acceptable internal reliability (Bergman, et al., 2011). We translated the CHDKQ into ASL and CASE and also produced a spoken language version, to respectively assess D/HH and hearing adolescents' cardiovascular knowledge independent of their reading skills. We focused on cardiovascular health knowledge because cardiovascular disease is a critical concern for D/HH people (Jones, Renger, & Firestone, 2005).

**Original interactive and critical health literacy measures—**Based on the major themes that emerged from formative interviews with 20 D/HH high school students (Smith et al., 2015), we developed several original self-report items about specific interactive and critical health literacy skills (see Table 4). These items were then translated into ASL and CASE as well as spoken English. Participants rated all items on a 1–5 Likert scale. An example item is “How easy is it for you to decide if health information that you get from other people is true or false? (1=very difficult, 2=difficult, 3=somewhat difficult, 4= easy, 5=very easy)”

**Demographics—**We developed items about general, social, and deaf-related demographic characteristics that influence language, educational, and cognitive development potentially important for D/HH and hearing adolescents' health literacy (See Table 1). Childhood SES was assessed based on participants' parents' education levels, one of three traditional SES proxies for adolescents (Lien, Friestad, & Klepp, 2001). Participants reporting both parents had at most a high school education or attended vocational/technical school were classified as low childhood SES. Participants reporting one or more parent had some college education or greater were classified as high childhood SES. All items were translated into ASL and CASE as well as spoken language to test D/HH and hearing adolescents, respectively, independent of their reading skills.

## Procedure

**Translation and video production—**We extensively pre-tested and revised the initial written version of all survey measures with 18 individuals, including content-expert and content-naïve deaf and hearing colleagues, teachers, interpreters, and students, to improve

the items' comprehension ease and face validity. To respect the diversity of sign languages within the Deaf community, we followed basic protocols for translation, adaptation, back translation, cognitive interview, and studio production procedures described in other health survey research with deaf people (Graybill et al., 2010; Pollard, Dean, O'Hearn, & Haynes, 2009). We convened 5 bilingual ASL/English experts and community members to translate by consensus the written English of the instrument's instructions and content into ASL. A second group of 5 bilingual English/CASE experts and community members translated by consensus the same materials into Conceptually Accurate Sign English. All materials were back translated into English by three independent bilingual community members to validate the faithfulness of these translations. Four D/HH students produced the material in sign language on camera. These models varied in gender, race, and sign language type to provide a diverse choice of survey presenters.

To provide more comparable testing conditions for D/HH and hearing adolescents and to control for the possibility that some hearing adolescents might have poor reading skills, we created a spoken English version of all signed measures. Four hearing models that matched the D/HH models in gender and racial diversity were video-recorded speaking the items.

**Cognitive testing and survey construction**—We programmed all measures on touch-screen laptops. We developed a new computer interface to present the HLSI-SF and S-TOFHLA and presented the remaining survey items using a video-enabled interface developed by the National Center for Deaf Health Research (Samar, Barnett, Oyzon, Mowl, & Sutter, 2012; Barnett et al., 2011; Graybill et al., 2010). In addition to the signed or spoken videos, these interfaces also presented the printed text of all measures. We named the full collection of measures the “Health Literacy Survey for Young People” (HLSYP). We pilot-tested the HLSYP with in-depth cognitive interviews of four female and two male sign language-using deaf college students, which led to minimal changes in the survey instructions as well as some adjustments in the survey format and item order to improve the comprehensibility and flow of the survey.

**Data collection**—Participants took the HLSYP anonymously on laptop computers at their own pace in small groups of 12–16 seated around large classroom tables prior to a scheduled workshop on public health issues and research methods.

**Data analysis**—We used analyses of covariance (ANCOVA) for the standard health literacy outcome measures and logistic regressions for the interactive and critical health literacy measures with hearing status (D/HH vs. hearing) as a between subjects factor to test for group performance disparities. We also conducted within group ANCOVAs using interactive and critical health literacy categories and deaf-related demographic categories as between-subjects factors to predict the three standard health literacy measures. All ANCOVAs and logistic regressions included covariates to adjust for age, grade, gender, race/ethnicity, and childhood socioeconomic status. Race/ethnicity was recoded as White/non-Hispanic and Other to provide a dichotomous covariate.

## Results

### Demographics

Table 1 summarizes the participant groups' demographic characteristics. Approximately 39% of the D/HH participants did not complete the survey, while 100% of the hearing participants completed the survey. In addition, some students skipped various questions. Therefore, the group numbers in Table 1 vary. D/HH participants were significantly older, more frequently male, in higher grades, from lower childhood socioeconomic homes and tended to be more frequently white non-Hispanic compared with hearing participants.

D/HH participants reported a very broad range of hearing loss, with and without assistive devices. Approximately two-thirds reported having hearing aids and one-third reported having cochlear implants. D/HH participants described a wide range of cultural identities including individuals who described themselves as “culturally deaf” or “deaf “to individuals who described themselves as “hard-of-hearing”, “hearing impaired”, or “hearing”. They also reported a range of best languages ranging from ASL, to equivalent competence in ASL and English, and to English. Approximately 78% reported hearing loss onset before age 3 and the large majority reported having hearing parents and family members.

### Group Comparisons on Standard Health Literacy Measures

Table 2 compares the D/HH and hearing participants on the three standard health literacy measures (HLSI-SF, S-TOFHLA, and CHDKQ). Controlling for general demographics, D/HH adolescents had significantly lower scores than hearing adolescents on all three measures (all  $p$ 's<0.001).

We further adjusted the regression equations predicting each health literacy measure by including the two remaining health literacy measures as covariates. This procedure allowed us to evaluate for group disparities in each health literacy measure that were specific to that measure. Table 3 reveals that D/HH adolescents continued to demonstrate lower scores on each health literacy measure after adjusting simultaneously for demographic variables and for performance on the other two health literacy measures.

### Group Comparisons on Interactive and Critical Health Literacy Skills and Experiences

Table 4 shows that D/HH adolescents differed significantly from hearing adolescents with more trouble: 1) creating healthy environment for themselves; 2) determining the accuracy of health information obtained from other people; 3) deciding how much exercise is needed to stay healthy; and 4) deciding when they needed to go see a doctor. D/HH and hearing adolescents reported similar frequency of family discussion about family health history, and similar ability to determine the accuracy of printed health information, what foods are healthy to eat, and when to talk to their doctors about their family health history.

### Relationships between Interactive and Critical Health Literacy Skills/Experiences and Standard Health Literacy Measures

Table 5 reveals that D/HH adolescents who reported having more frequent family discussions about their family health history had higher HLSI-SF and S-TOFHLA scores



than D/HH adolescents who had fewer such discussions. Furthermore, D/HH adolescents who reported having an easier time determining the truth of printed health information had higher HLSI-SF and CHDKQ scores than those who reported having trouble making such decisions. In addition, those who reported an easier time determining the accuracy of health information obtained from other people had higher CHDKQ scores. These relationships were not significant for hearing adolescents.

D/HH adolescents who reported having an easier time deciding when they needed to see a doctor had higher HLSI, S-TOFHLA, and CHDKQ scores. Those who reported having an easier time deciding when they needed to talk to their doctors about their family medical history, how much exercise they need to stay healthy, and which foods are healthy to eat had higher CHDKQ scores. Those who reported having an easier time deciding how much exercise they need to stay healthy and which foods are healthy to eat had higher HLSI scores. Hearing adolescents generally demonstrated similar patterns in these relationships.

### **Relationships between D/HH Demographic Factors and Standard Health Literacy Measures**

Table 6 shows that D/HH adolescents who had higher S-TOFHLA scores included those who: 1) described themselves as being hearing/hearing impaired/hard-of-hearing; 2) reported having better hearing with assistive devices; 3) reported having hearing aids; 4) reported wearing their hearing aids frequently; 5) described English as their best language; 6) reported good quality of communication with their parents; and 7) reported attending hearing schools at least half of the time. D/HH adolescents who had higher cardiovascular health knowledge scores included those who reported wearing their hearing aids frequently, described English as their best language, and reported attending hearing schools at least half of the time.

Having a cochlear implant (CI) per se was not related to D/HH adolescents' HLSI, S-TOFHLA, or CHDKQ scores. However, of the D/HH adolescents who reported having a CI, those who used their CI more frequently showed a trend toward higher HLSI scores ( $p=0.071$ ). Otherwise, D/HH adolescents' reports of their degree of hearing loss without assistive devices, their age of onset of deafness, their preferences for socializing with deaf versus hearing friends, and the presence or absence of deaf family members were not related to their HLSI, S-TOFHLA, and CHDKQ scores.

### **Discussion**

Using culturally and linguistically appropriate measures of health literacy adapted for both D/HH and hearing adolescents, our findings indicate that D/HH adolescents have significantly weaker general health literacy, functional health literacy, and cardiovascular health knowledge than their hearing adolescent peers. These health literacy disparities emerged despite controlling for common demographic variables that might influence health literacy in general populations, including age, grade, gender, race/ethnicity, and socioeconomic status. Importantly, D/HH adolescents' disparities on each of the three standard health literacy measures persisted even when adjusted for the two other measures. The fact that a significant portion of D/HH participants were slower than hearing

participants in responding to survey items is consistent with our finding of their broad health literacy and knowledge weaknesses.

Our results agree with contemporary views that health literacy is a multidimensional construct encompassing functional, interactive, and critical health literacy skills and experiences as well as health knowledge. Our results also provide the first evidence that this view also applies to D/HH adolescents. The fact that controlling for functional health literacy did not eliminate the disparities between D/HH and hearing adolescents on general health literacy and cardiovascular health knowledge measures supports the hypothesis that D/HH people's health literacy challenges extend beyond the narrow construct captured by functional health literacy measures. This, in turn, suggests that measures of functional health literacy are insufficient to characterize the full range of health literacy challenges faced by D/HH people. Therefore, even D/HH adolescents who have stronger English language skills may be at increased risk for weaker health literacy.

Having frequent family discussions about family health history was positively associated with greater general health literacy (HLSI) and greater functional health literacy (S-TOFHLA) for D/HH but not hearing adolescents. Since the HLSI scores were broadly distributed for both D/HH and hearing groups, the absence of this effect for hearing adolescents was not due to any relatively greater range restriction on the hearing adolescent's HLSI scores because of their overall superior health literacy (interquartile range: Hearing, 7–9; D/HH, 4–7). Rather, we speculate that family conversations play a more critical role for deaf children than for hearing children in their development of health literacy skills. Family conversations and other incidental sources of health knowledge are crucial for developing strong health literacy skills (Smith et al., 2015). Hearing adolescents who do not directly discuss health issues with their families nevertheless might overhear conversations about family health among immediate or extended family members and friends or through the media, whereas D/HH adolescents generally have limited access to such incidental sources. Our finding that the relationship occurred for D/HH adolescents but not for hearing adolescents agrees with these considerations.

The frequency of family health conversations was also positively related to functional health literacy in D/HH but not hearing adolescents. Hearing adolescents did show a highly restricted range of S-TOFHLA scores compared with D/HH adolescents (interquartile range: Hearing, 34–36; D/HH, 21–33), perhaps because the S-TOFHLA is heavily dependent on reading ability, which does not vary greatly in hearing adolescents. Since reading skill is the primary determinant of S-TOFHLA scores, the failure of frequent family discussion to be associated with S-TOFHLA for hearing adolescents might therefore be explained by the severe restriction on variability in reading ability in our hearing sample. Nevertheless, it remains possible that frequency of family health discussion might relate significantly to functional health literacy in a general-population sample of hearing adolescents with a greater expected range of reading skill. Nevertheless, our finding of this relationship for academically select D/HH adolescents underscores the pervasiveness of functional health literacy deficits in the D/HH population regardless of their education level.

D/HH adolescents who reported that they could easily evaluate the accuracy of printed health information had greater general health literacy (HLSI) and greater cardiovascular health knowledge (CHDKQ) than other D/HH adolescents. Furthermore, D/HH adolescents who reported that they could easily evaluate health information obtained from other people and who could easily decide when to talk to a doctor about their family's medical history had greater cardiovascular health knowledge than other D/HH adolescents. In contrast, hearing adolescents did not show these relationships. Again, these results could not be explained by any selective restriction on score ranges for hearing adolescents for the HLSI or the CHDKQ (interquartile range: Hearing, 26.7–50; D/HH, 41.0–63.3). Rather, these results are consistent with the claim that due to their greater communication skills and social access during childhood, hearing adolescents' health literacy skills are shaped by redundant access to multiple alternative sources of common health information. Collectively, these results suggest that critical and interactive measures of health-related behaviors and experiences are more significant and informative markers of overall health literacy in deaf adolescents than in hearing adolescents.

Other interactive and critical health literacy behaviors and experiences shown in Table 5 were related to standard health literacy measures in both deaf and hearing participant groups. Ease of deciding which foods are healthy, ease of deciding the amount of exercise to stay healthy, and ease of deciding when to see a doctor were related to one or more of the three standard health literacy measures in both D/HH and hearing participants. These relationships underscore the potential value of including specific direct interactive and critical health literacy measures in comprehensive health literacy assessments of both D/HH and hearing adolescents.

Analyses of deafness-related demographic subgroups revealed relationships primarily related to functional health literacy. D/HH adolescents who reported severe hearing loss even with assistive devices or who reported not having or not frequently using hearing aids had lower S-TOFHLA scores than other deaf adolescents. However, having or frequently using a cochlear implant was not clearly related to D/HH adolescents' health literacy.

D/HH adolescents who reported a deaf cultural identity, having sign language as their best language, having poor quality of communication with their parents, or having attended mostly deaf schools had lower functional health literacy and cardiovascular health knowledge than other D/HH adolescents. These results suggest that cultural, social and family communication factors may influence deaf adolescents' health literacy development. However, the reported hearing status of parents, siblings, extended family, or social group members did not significantly relate to any standard health literacy measures. It is possible that survey items such as those represented in Table 1 that measure hearing status of family and peers may be less reliable proxies for communication quality than direct questions about childhood communication experiences. Further research is necessary to verify and reconcile these results.

As adolescence is a critical developmental period for health education interventions, we should increase our efforts to develop targeted health education and interventions for this population. Such efforts should include educating families of D/HH children to include their

children and adolescents in more conversations about their health history, which might help to compensate for the barriers they experience in gaining access to indirect incidental family health information and general health knowledge from health care professionals and media sources.

D/HH adolescents would also benefit from improved access to printed health information in general. Printed health information designed for D/HH adolescents should use simpler English grammar and vocabulary, and more visual information (pictures, models, etc.). Further research and effort is needed to make the production of simplified printed health information more efficient and effective, such as automated text simplification programs (Leroy, Endicott, Kauchak, Mouradi, & Just, 2013). Such materials, tailored to the English language skills and visual learning competencies of D/HH adolescents would help to compensate for the health information that they otherwise miss in their environments. Moreover, increasing the number of well-qualified healthcare sign language interpreters and promoting the use of these interpreters for D/HH children's interactions with health care providers would also help to improve D/HH adolescents' access to health information from health professionals who do not use sign language (Smith et al., 2015).

This study used cross-sectional survey data and therefore causal inferences about correlated findings cannot be made. In addition, random uncontrollable factors such as strict survey time limits as dictated by program schedules caused some participants not to complete their surveys, weakening the statistical power of our comparisons. The strict time limit also did not allow us to obtain an independent standardized measure of reading level from our participants. However, this limitation is mitigated by the fact that the S-TOFHLA is generally recognized as a reading comprehension measure, since it uses a cloze procedure and is based specifically on the reading comprehension part of the TOFHLA (Hoffman, et al., 2013). That reading comprehension part has been demonstrated to have good convergent validity with the WRAT as a literacy measure for adolescents (Chisolm & Buchanan, 2007). Therefore, using the S-TOFHLA as a covariate in regression analyses that predict group disparities in the HLSI and CHDKQ measures allowed us to essentially account for variance associated with reading comprehension.

The use of a national convenience sample of only college-bound adolescents limits the generalizability of study results and findings. Although the D/H and hearing samples were well match academically, they clearly do not represent the range of academic and communication skills present in the general D/HH or hearing adolescent populations. Studies that compare D/HH and hearing groups inevitable face many potentially uncontrollable sampling biases, such as biases due to geographically local sampling, differences in developmental, socioeconomic, and academic attainment variables. A positive aspect of our particular convenience sample is that by partnering with college exploration programs, we were able to compare national samples of academically successful D/HH and hearing individuals across multiple social strata.

A factor that might have contributed to the observed group differences is potential differences in the general interest of the two participant groups in health-related issues. The hearing participants were attending a summer program for adolescents who had a general

interest in pursuing health careers, whereas the D/HH participants attended a broader career exploration camp. It is possible that the hearing participants might have been more likely to have sought out information about various health-related topics. This could cause them to do better on health literacy measures regardless of their long history of better communication and access to formal and incidental information in social and health care environments. If a general interest in health-related topics caused the hearing participants to have generally greater health literacy and health-related knowledge, we might expect the size of the group disparity to be correlated across our three standard health literacy and knowledge measures, since greater interest should motivate specific individuals to seek more or less broad exposure to information across several domains of health literacy and knowledge. However, our results indicate that the D/HH versus hearing group disparity on each of the three health literacy and knowledge measures remained even after statistically controlling scores on the other two measures. These results suggest that the group disparities were not correlated, but were domain-specific and likely stemmed from distinct underlying deaf-related factors rather than from a general sample difference in the overall level of interest in health topics. However, we cannot completely rule out a contribution of differences in the overall level of interest to the group disparities and future research should more rigorously control for this potential factor.

Although we have controlled for several demographic variables, we note that childhood SES and race/ethnicity are multidimensional constructs and our measures only crudely controlled for these social determinants of health literacy and knowledge. Future research should include additional measures and categories (Lien et al, 2001).

Our adapted HLSI version eliminated artificial influences of test format-related language on overall health literacy measurement, but retained significant English content in the test's health-related materials. This procedure maintained the test's component sensitivity to functional health literacy given real-world health information sources, an important issue for deaf adolescents (Smith et al., 2015). Limited ability of the D/HH participants to process the English content could have partially but not fully depressed HLSI scores because the HLSI disparity remained even after controlling statistically for the effect of functional health literacy using the S-TOFHLA. Furthermore, this possibility cannot explain the overall pattern of depressed health literacy and health knowledge, which was broadly expressed in our other translated measures. Future research should explore the effect of fully translating all reference materials in the HLSI to eliminate the functional health literacy contribution on its measurement outcomes.

Traditional methods such as the standard health literacy measures used in this study, even if linguistically and culturally adapted for D/HH populations, may not adequately assess the health literacy and health-related knowledge of D/HH individuals. The D/HH community prefers to acquire and share information through dialogic interactions between community members, as opposed to the typical monologic format of educational presentations or survey tools. (Pollard et al., 2009). Dialogic assessment protocols and novel interactive tools that respect the sociolinguistic norms of the D/HH community should be developed and explored in future research.

## Conclusion

D/HH adolescents, especially those who use sign language to communicate with professionals and educators who do not use sign language, are at increased risk for weak overall, interactive, and critical health literacy, and health knowledge that extend beyond their functional health literacy deficits. Interventions to improve D/HH adolescents' health literacy should target family-oriented activities to improve their access to conversations about health, adaptation of printed health information to match their English language and visual learning competencies, and interpreter-aided access to health information from health care providers and educators who do not use sign language.

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**Table 1**

Demographics of D/HH and Hearing Study Participants

| Demographic                                     | Level  | Hearing Status |             |         |             |
|---|--|----------------|-------------|---------|-------------|
|   |  | D/HH           |             | Hearing |             |
|   |  | N              | M (SD) or % | N       | M (SD) or % |
| Age <sup>*****</sup>                            |  | 154            | 17.0 (.84)  | 89      | 15.8 (1.1)  |
| Gender <sup>**</sup>                            | Male   | 83             | 53.2        | 30      | 33          |
|   | Female   | 73             | 46.8        | 61      | 67          |
| Grade <sup>*****</sup>                          | 8th  |                |             | 8       | 8.8         |
|   | 9th  |                |             | 14      | 15.4        |
|   | 10th   | 31             | 20          | 27      | 29.7        |
|   | 11th   | 86             | 55.5        | 36      | 39.5        |
|   | 12th   | 38             | 24.5        | 5       | 5.5         |
|   | 13th   |                |             | 1       | 1.1         |
| Hispanic ethnicity                              | Yes  | 31             | 20.3        | 12      | 13.2        |
|   | No   | 122            | 79.7        | 79      | 86.8        |
| Race <sup>†</sup>                               | White  | 95             | 63.3        | 47      | 51.6        |
|   | African American                                 | 13             | 8.7         | 17      | 18.7        |
|   | Asian  | 12             | 8           | 9       | 9.9         |
|   | Native Hawaiian or other PI                      | 1              | 0.7         |         |             |
|   | Native American, American Indian, Alaskan Native | 8              | 5.3         | 1       | 1.1         |
| Childhood socioeconomic status <sup>*****</sup> | Other  | 21             | 14          | 17      | 18.7        |
|   | Low  | 41             | 29.7        | 6       | 6.8         |
|   | High   | 97             | 70.3        | 82      | 93.2        |
| Cultural identity                               | Culturally Deaf                                  | 25             | 17.4        |         |             |
|   | Deaf   | 63             | 43.8        |         |             |
|   | Hard of hearing                                  | 35             | 24.3        |         |             |

| Demographic                        | Level                   | Hearing Status |             |         |             |
|------------------------------------|-------------------------|----------------|-------------|---------|-------------|
|                                    |                         | D/HH           |             | Hearing |             |
|                                    |                         | N              | M (SD) or % | N       | M (SD) or % |
|                                    | Hearing impaired        | 16             | 11.1        |         |             |
|                                    | Hearing                 | 3              | 2.1         | 91      | 100         |
|                                    | Other                   | 2              | 1.4         |         |             |
| Best language                      | ASL/Sign Language       | 38             | 26.8        |         |             |
|                                    | English                 | 49             | 34.5        | 88      | 96.7        |
|                                    | Both ASL and English    | 55             | 38.7        |         |             |
|                                    | Other Language          |                |             | 3       | 3.3         |
| Age onset of deafness              | At birth                | 77             | 53.9        |         |             |
|                                    | By 3 years              | 34             | 23.8        |         |             |
|                                    | After 3 years           | 22             | 15.4        |         |             |
|                                    | Are Hearing             | 2              | 1.4         | 91      | 100         |
|                                    | Don't know              | 8              | 5.6         |         |             |
| Deaf parents                       | One or more deaf        | 20             | 14.2        |         |             |
|                                    | Hearing                 | 121            | 85.8        |         |             |
| Deaf immediate family              | One or more deaf        | 35             | 24.8        |         |             |
|                                    | Hearing                 | 106            | 75.2        |         |             |
| Deaf extended family               | One or more deaf        | 45             | 31.9        |         |             |
|                                    | Hearing                 | 98             | 68.1        |         |             |
| Have hearing aid                   | Yes                     | 93             | 64.1        |         |             |
|                                    | No                      | 52             | 35.9        |         |             |
| Have cochlear implant              | Yes                     | 52             | 37.1        |         |             |
|                                    | No                      | 88             | 62.9        |         |             |
| Hearing without hearing assistance | 1 = You hear everything | 8              | 5.7         |         |             |

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| Demographic                     | Level                   | Hearing Status |             |   |             |
|---------------------------------|-------------------------|----------------|-------------|---|-------------|
|                                 |                         | D/HH           | Hearing     |   |             |
|                                 |                         | N              | M (SD) or % | N | M (SD) or % |
|                                 | 2                       | 12             | 8.5         |   |             |
|                                 | 3                       | 40             | 28.4        |   |             |
|                                 | 4                       | 28             | 19.9        |   |             |
|                                 | 5 = You hear nothing    | 53             | 37.6        |   |             |
| Hearing with hearing assistance | 1 = You hear everything | 31             | 27.2        |   |             |
|                                 | 2                       | 29             | 25.4        |   |             |
|                                 | 3                       | 19             | 16.7        |   |             |
|                                 | 4                       | 17             | 14.9        |   |             |
|                                 | 5 = You hear nothing    | 18             | 15.8        |   |             |

!  $p < .1$ ,

\*  $p < .05$ ,

\*\*  $p < .01$ ,

\*\*\*\*  $p < .0001$

Mean Performance Scores on Standard Health Literacy Measures of D/HH and Hearing Adolescents Adjusted for Age, Grade, Gender, Race/Ethnicity, and Childhood Socioeconomic Status

Table 2

| Standard Health Literacy Measure | Hearing Status |                        |          |                        | Statistics<br><i>F</i> ( <i>df</i> 1, <i>df</i> 2), <i>p</i> |
|----------------------------------|----------------|------------------------|----------|------------------------|--|
|                                  | D/HH           |                        | Hearing  |                        |  |
|                                  | <i>N</i>       | <i>M</i> ( <i>CI</i> ) | <i>N</i> | <i>M</i> ( <i>CI</i> ) |  |
| HLSI                             | 186            | 5.0<br>(4.5–5.6)       | 93       | 7.6<br>(6.9–8.2)       | 73.9(1,207), .0001   |
| S-TOFHLA                         | 185            | 25.6<br>(23.7–27.4)    | 91       | 31.5<br>(29.4–33.6)    | 38.5(1,205), .0001   |
| CHDKQ<br>(%correct)              | 104            | 30.6<br>(25.0–36.3)    | 90       | 48.4<br>(42.2–54.6)    | 39.2(1,167), .0001   |

D/HH Versus Hearing Group Comparisons on the HLSI, S-TOFHLA, and CHDKQ Adjusted for Age, Grade, Gender, Race/Ethnicity, Childhood Socioeconomic Status, and Different Health Literacy Measures

Table 3

| Standard Health Literacy Measure | Group |                     |                        | Statistics             |
|----------------------------------|-------|---------------------|------------------------|------------------------|
|                                  | D/HH  | Hearing             | F(df1,df2), p          |                        |
|                                  | N     | M (CI)              | N M (CI)               |                        |
| HLSI                             | 186   | 6.1<br>(5.5–6.7)    | 93 7.6<br>(7.0–8.2)    | 0.5 (1,161), .001<br>2 |
| S-TOFHLA                         | 185   | 29.0<br>(27.2–30.9) | 91 3<br>(29.1–34.7)    | 3.6 (1,161), .060      |
| CHDKQ (%correct)                 | 104   | 35.6<br>(29.5–41.6) | 90 45.4<br>(39.2–51.6) | 8.8 (1,161), .004      |

**Table 4**  
Interactive and Critical Health Literacy Skills and Experiences of D/HH and Hearing Adolescents Adjusted for Age, Grade, Gender, Race/Ethnicity, and Childhood Socioeconomic Status

| Interactive and Critical Health Literacy Skills and Experiences      | Level                                     | Hearing Status |       |         |       | Statistics      |
|--|---|----------------|-------|---------|-------|-----------------|
|  |   | D/HH           |       | Hearing |       |                 |
|  |   | N              | %     | N       | %     |                 |
| Frequency of family discussions about family health history          | Never to Sometimes<br>Often to Very Often | 86             | 93.48 | 82      | 90.80 | 1.7 (1), ns     |
| Ease of creating a healthy environment for self                      | Hard<br>Easy                              | 50             | 57.47 | 35      | 38.46 | 12.0 (1), .0005 |
| Ease of deciding truth of printed health information                 | Hard<br>Easy                              | 60             | 68.97 | 58      | 64.44 | 1.0 (1), ns     |
| Ease of deciding truth of health information from other people       | Hard<br>Easy                              | 68             | 79.07 | 59      | 64.84 | 8.0 (1), .0048  |
| Ease of deciding which foods are healthy                             | Hard<br>Easy                              | 23             | 26.44 | 16      | 17.58 | 1.7 (1), ns     |
| Ease of deciding amount of exercise                                  | Hard<br>Easy                              | 64             | 73.56 | 75      | 82.42 |                 |
| Ease of deciding when to talk to doctor about family medical history | Hard<br>Easy                              | 34             | 39.53 | 29      | 32.22 | 3.1 (1), .0762  |
| Frequency of events that make you think                              | Never to sometimes                        | 54             | 63.53 | 60      | 67.42 | 0.0 (1), ns     |

| Interactive and Critical Health Literacy Skills and Experiences | Level               | Hearing Status |       |         |       | Statistics<br><i>chi2(df), p</i> |
|---|---------------------|----------------|-------|---------|-------|----------------------------------|
|   |                     | D/HH           |       | Hearing |       |                                  |
|   |                     | N              | %     | N       | %     |                                  |
| about health  | Often to very often | 31             | 36.47 | 29      | 32.58 |                                  |
| Ease of deciding when to see a doctor                           | Hard                | 41             | 50.00 | 24      | 26.97 | 6.3 (1), .0120                   |
|   | Easy                | 41             | 50.00 | 65      | 73.03 |                                  |

**Table 5**

Mean Performance Scores on Standard Health Literacy Measures of Deaf/HH and Hearing Adolescents as a Function of Interactive and Critical Health Literacy Skills and Experiences Adjusted for Age, Grade, Gender, Race/Ethnicity, and Childhood Socioeconomic Status

| Interactive and Critical Health Literacy Skills and Experiences | Level               | N  | Hearing Status                         |  |   |  |  |   |
|---|---------------------|----|--|--|---|--|--|---|
|   |                     |    | D/HH                                   |  |   | Hearing                                |  |   |
|   |                     |    | HLSI<br><i>Adj. M</i><br>( <i>SE</i> ) | S-<br>TOFHLA<br><i>Adj. M</i><br>( <i>SE</i> ) | CHDKQ<br><i>Adj. M</i><br>( <i>SE</i> ) | HLSI<br><i>Adj. M</i><br>( <i>SE</i> ) | S-<br>TOFHLA<br><i>Adj. M</i><br>( <i>SE</i> ) | CHDKQ<br><i>Adj. M</i><br>( <i>SE</i> ) |
| Frequency of family discussions about family medical history    | Never to Sometimes  | 86 | 5.02 <sup>a</sup><br>(.27)             | 27.14 <sup>b</sup><br>(.88)                    | 36.96<br>(2.30)                         | 7.74<br>(.38)                          | 33.79<br>(.44)                                 | 52.04<br>(4.21)                         |
| Ease of creating a healthy environment for self                 | Often to Very Often | 6  | 7.04 <sup>a</sup><br>(1.00)            | 34.28 <sup>b</sup><br>(3.19)                   | 34.30<br>(8.35)                         | 7.54<br>(.64)                          | 33.89<br>(.76)                                 | 44.06<br>(7.44)                         |
| Ease of deciding truth of printed health information            | Easy                | 37 | 4.81<br>(.34)                          | 27.05<br>(1.18)                                | 35.11<br>(2.89)                         | 7.62<br>(0.43)                         | 33.74<br>(0.52)                                | 51.36<br>(4.99)                         |
| Ease of deciding truth of health information from other people  | Hard                | 50 | 5.48<br>(.36)                          | 27.48<br>(1.24)                                | 40.90<br>(3.03)                         | 7.81<br>(0.40)                         | 33.81<br>(0.46)                                | 52.40<br>(4.44)                         |
| Ease of deciding truth of health information from other people  | Hard                | 60 | 4.83 <sup>c</sup><br>(.31)             | 26.47<br>(1.07)                                | 35.02 <sup>d</sup><br>(2.61)            | 7.57<br>(0.46)                         | 33.75<br>(0.51)                                | 50.76<br>(4.81)                         |
| Ease of deciding truth of health information from other people  | Easy                | 27 | 5.74 <sup>c</sup><br>(.41)             | 28.83<br>(1.41)                                | 43.50 <sup>d</sup><br>(3.44)            | 7.6<br>(0.45)                          | 33.8<br>(0.53)                                 | 55.27<br>(5.09)                         |
| Ease of deciding truth of health information from other people  | Hard                | 68 | 5.13<br>(.28)                          | 27.02<br>(0.98)                                | 36.22 <sup>aa</sup><br>(2.32)           | 7.62<br>(0.41)                         | 33.48<br>(0.5)                                 | 47.12<br>(4.75)                         |
| Ease of deciding truth of health information from other people  | Easy                | 18 | 5.09<br>(.60)                          | 28.88<br>(2.08)                                | 49.65 <sup>aa</sup><br>(4.93)           | 7.98<br>(0.43)                         | 33.6<br>(0.52)                                 | 53.45<br>(4.97)                         |
| Ease of deciding which foods are healthy                        | Hard                | 23 | 4.47 <sup>f</sup><br>(.45)             | 27.02<br>(1.57)                                | 28.20 <sup>bb</sup><br>(3.62)           | 7.65<br>(0.48)                         | 32.81 <sup>e</sup><br>(.59)                    | 52.09<br>(5.66)                         |
| Ease of deciding amount of exercise                             | Easy                | 64 | 5.42 <sup>f</sup><br>(.31)             | 27.39<br>(1.08)                                | 42.00 <sup>bb</sup><br>(2.50)           | 7.78<br>(0.40)                         | 34.06 <sup>e</sup><br>(0.44)                   | 52.05<br>(4.39)                         |
| Ease of deciding amount of exercise                             | Hard                | 34 | 4.32 <sup>cc</sup><br>(.36)            | 26.35<br>(1.31)                                | 31.92 <sup>dd</sup><br>(3.09)           | 7.76<br>(0.41)                         | 33.13 <sup>f</sup><br>(.49)                    | 46.77 <sup>g</sup><br>(4.80)            |



|   |                     | Hearing Status |                             |                               |                               |    |                  |                              |                              |   |                  |                      |                   |
|---|---------------------|----------------|-----------------------------|-------------------------------|-------------------------------|----|------------------|------------------------------|------------------------------|---|------------------|----------------------|-------------------|
|   |                     | D/HH           |                             |                               |                               |    | Hearing          |                              |                              |   |                  |                      |                   |
| Interactive and Critical Health Literacy Skills and Experiences | Level               | N              | HLSI Adj. M (SE)            | S-TOFHLA Adj. M (SE)          | CHDKQ Adj. M (SE)             | N  | HLSI Adj. M (SE) | S-TOFHLA Adj. M (SE)         | CHDKQ Adj. M (SE)            | N | HLSI Adj. M (SE) | S-TOFHLA Adj. M (SE) | CHDKQ Adj. M (SE) |
|   | Easy                | 52             | 5.74 <sup>cc</sup><br>(.31) | 27.95<br>(1.15)               | 42.20 <sup>dd</sup><br>(2.72) | 61 | 7.72<br>(0.4)    | 34.17 <sup>f</sup><br>(0.45) | 55.25 <sup>g</sup><br>(4.41) |   |                  |                      |                   |
|   | Hard                | 47             | 4.88<br>(.34)               | 26.19<br>(1.15)               | 34.20 <sup>h</sup><br>(2.81)  | 90 | 7.87<br>(0.41)   | 33.77<br>(0.47)              | 50.17<br>(4.51)              |   |                  |                      |                   |
|   | Easy                | 38             | 5.45<br>(.38)               | 28.45<br>(1.28)               | 42.10 <sup>h</sup><br>(3.12)  | 86 | 7.62<br>(0.41)   | 33.8<br>(0.49)               | 54.46<br>(4.68)              |   |                  |                      |                   |
|   | Never to Sometimes  | 54             | 5.17<br>(.34)               | 27.66<br>(1.12)               | 37.14<br>(2.78)               | 60 | 7.68<br>(0.38)   | 33.81<br>(0.37)              | 50.99<br>(4.11)              |   |                  |                      |                   |
|   | Often to Very Often | 31             | 5.26<br>(.45)               | 26.66<br>(1.48)               | 39.34<br>(3.68)               | 29 | 7.86<br>(0.45)   | 33.46<br>(0.46)              | 53.98<br>(4.99)              |   |                  |                      |                   |
|   | Hard                | 41             | 4.65 <sup>/</sup><br>(.38)  | 25.56 <sup>ee</sup><br>(1.21) | 33.47 <sup>i</sup><br>(3.23)  | 24 | 7.72<br>(0.56)   | 34.33<br>(0.54)              | 43.65 <sup>/</sup><br>(6.11) |   |                  |                      |                   |
|   | Easy                | 41             | 5.49 <sup>/</sup><br>(.36)  | 29.69 <sup>ee</sup><br>(1.13) | 41.38 <sup>i</sup><br>(3.01)  | 65 | 7.86<br>(0.45)   | 34.91<br>(0.42)              | 51.02 <sup>/</sup><br>(4.75) |   |                  |                      |                   |

<sup>/</sup> p<.1; paired single superscript letters (e.g., a through i) denote significant differences between pairs of means at the .05 level; paired double superscript letters (e.g., aa through ee) denote significant differences between pairs of means at the .01 level.

**Table 6**

Mean Health Literacy Scores of D/HH Adolescents with Various Deaf-Related Demographics Adjusted for Age, Grade, Gender, Race/Ethnicity, and Childhood Socioeconomic Status

| Deaf-Related Demographic          | Level                     | N          | HLSI        |        |              | S-TOFHILA     |             |              | CHDKQ        |             |      |
|-----------------------------------|---------------------------|------------|-------------|--------|--------------|---------------|-------------|--------------|--------------|-------------|------|
|                                   |                           |            | Adj. M (SE) | F (df) | p            | Adj. M (SE)   | F (df)      | p            | Adj. M (SE)  | F (df)      | p    |
| Cultural identity                 | Deaf                      | 88         | 4.96 (.26)  |        |              | 24.74 (.92)   | 5.4 (1,113) | .025         | 36.26 (2.52) |             |      |
| Hearing without assistive devices | Hard-of-hearing           | 56         | 5.28 (.31)  |        |              | 27.73 (1.08)  |             |              | 37.68 (2.91) |             |      |
|                                   | Hearing impaired          |            |             |        |              |               |             |              |              |             |      |
|                                   | Hearing                   |            |             |        |              |               |             |              |              |             |      |
| Hearing with assistive devices    | Mild loss                 | 20         | 5.05 (.52)  |        |              | 27.91 (1.83)  |             |              | 34.71 (4.60) |             |      |
|                                   | Moderate to profound loss | 121        | 5.22 (.24)  |        |              | 25.66 (.85)   |             |              | 36.46 (2.27) |             |      |
|                                   | Mild loss                 | 60         | 5.38 (.30)  |        |              | 28.50 (.94)   | 8.2 (1,93)  | .006         | 37.29 (2.51) |             |      |
| Have hearing aid                  | Moderate to profound loss | 54         | 4.84 (.32)  |        |              | 25.05 (.99)   |             |              | 33.16 (2.78) |             |      |
|                                   | Yes                       | 93         | 5.17 (.26)  |        |              | 26.89 (.90)   | 5.4 (1,114) | .022         | 34.76 (2.37) |             |      |
| How often use hearing aid         | No                        | 52         | 4.90 (.33)  |        |              | 23.79 (1.13)  |             |              | 38.78 (3.12) |             |      |
|                                   | Infrequently              | 37         | 4.88 (.37)  |        |              | 25.30 (1.170) | 3.67 (1,72) | .059         | 30.49 (3.28) | 2.95 (1,53) | .092 |
| Have cochlear implant             | Frequently                | 56         | 5.13 (.36)  |        |              | 28.24 (1.13)  |             |              | 37.33 (2.84) |             |      |
|                                   | Yes                       | 53         | 5.49 (.34)  |        |              | 26.59 (1.24)  |             |              | 37.78 (3.48) |             |      |
| How often use cochlear implant    | No                        | 88         | 4.88 (.25)  |        |              | 25.36 (.89)   |             |              | 35.57 (2.29) |             |      |
|                                   | Infrequently              | 14         | 4.34 (.63)  |        |              | 25.05 (1.79)  | 3.39 (1,33) | .071         | 28.25 (8.81) |             |      |
| Frequently                        | 39                        | 5.89 (.52) |             |        | 24.32 (1.48) |               |             | 36.29 (6.71) |              |             |      |

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| Deaf-Related Demographic              | Level                  | N   | HLSI        |        |   | S-TOFHILA    |               |       | CHDKQ        |             |      |
|---------------------------------------|------------------------|-----|-------------|--------|---|--------------|---------------|-------|--------------|-------------|------|
|                                       |                        |     | Adj. M (SE) | F (df) | p | Adj. M (SE)  | F (df)        | p     | Adj. M (SE)  | F (df)      | p    |
| Age of onset of deafness              | Before 3               | 111 | 5.00 (.25)  |        |   | 26.00 (0.88) |               |       | 34.40 (2.34) |             |      |
|                                       | After 3                | 32  | 5.25 (.38)  |        |   | 25.13 (1.36) |               |       | 40.46 (3.56) |             |      |
| Best language                         | American Sign Language | 38  | 4.95 (.38)  |        |   | 23.47 (1.33) | 2.39 (2,111)  | .096  | 37.91 (3.50) | 4.43 (2,81) | .015 |
|                                       | English                | 49  | 5.19 (.34)  |        |   | 27.22 (1.20) |               |       | 41.53 (3.11) |             |      |
| Socialize                             | Both                   | 55  | 5.06 (.32)  |        |   | 26.32 (1.15) |               |       | 30.75 (2.80) |             |      |
|                                       | Deaf                   | 30  | 5.24 (.45)  |        |   | 25.85 (1.59) |               |       | 34.53 (3.89) |             |      |
| Deaf mother                           | Hearing                | 23  | 4.96 (.46)  |        |   | 27.6 (1.61)  |               |       | 40.79 (4.02) |             |      |
|                                       | Both                   | 87  | 5.06 (.26)  |        |   | 25.3 (.93)   |               |       | 34.77 (2.51) |             |      |
| Deaf father                           | Yes                    | 19  | 5.76 (.51)  |        |   | 26.99 (1.83) |               |       | 37.86 (4.26) |             |      |
|                                       | No or don't know       | 122 | 4.99 (.23)  |        |   | 25.65 (.84)  |               |       | 35.77 (2.19) |             |      |
| Deaf siblings                         | Yes                    | 16  | 5.51 (.55)  |        |   | 25.64 (1.99) |               |       | 36.61 (4.75) |             |      |
|                                       | No or don't know       | 126 | 5.01 (.23)  |        |   | 25.77 (.82)  |               |       | 36.03 (2.16) |             |      |
| Deaf extended family                  | Yes                    | 29  | 5.16 (.42)  |        |   | 25.48 (1.55) |               |       | 38.51 (3.73) |             |      |
|                                       | No or don't know       | 93  | 5.05 (.26)  |        |   | 25.91 (.98)  |               |       | 36.03 (2.39) |             |      |
| Quality of communication with parents | Yes                    | 16  | 5.35 (.43)  |        |   | 24.27 (1.52) |               |       | 36.23 (3.96) |             |      |
|                                       | No or don't know       | 126 | 5.03 (.24)  |        |   | 26.26 (.86)  |               |       | 36.07 (2.22) |             |      |
| Good                                  | Poor                   | 42  | 4.80 (.35)  |        |   | 22.00 (1.17) | 18.29 (1,107) | .0001 | 34.65 (3.17) |             |      |
|                                       | Good                   | 92  | 5.16 (.28)  |        |   | 28.25 (.95)  |               |       | 36.91 (2.52) |             |      |

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| Deaf-Related Demographic | Level       | N | HLSI          |        |   | S-TOFH/A        |                 |       | CHDKQ           |                |       |
|--------------------------|-------------|---|---------------|--------|---|-----------------|-----------------|-------|-----------------|----------------|-------|
|                          |             |   | Adj. M (SE)   | F (df) | p | Adj. M (SE)     | F (df)          | p     | Adj. M (SE)     | F (df)         | p     |
| Type of school           | Mostly deaf |   | 4.91<br>(.31) |        |   | 23.95<br>(1.09) | 5.36<br>(1,105) | .0225 | 32.52<br>(2.64) | 4.92<br>(1,82) | .0293 |
|                          |             |   | 5.07<br>(.29) |        |   | 27.09<br>(1.03) |                 |       | 40.11<br>(2.73) |                |       |