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# Bilingual approach to online cancer genetics education for deaf American Sign Language users produces greater knowledge and confidence than English text only: A randomized study

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## Abstract

**Introduction**—Deaf American Sign Language-users (ASL) have limited access to cancer genetics information they can readily understand, increasing risk for health disparities. We compared effectiveness of online cancer genetics information presented using a bilingual approach (ASL with English closed captioning) and a monolingual approach (English text).

**Hypothesis**—Bilingual modality would increase cancer genetics knowledge and confidence to create a family tree; education would interact with modality.

**Methods**—We used a block 2:1 randomized pre-post study design stratified on education. 150 Deaf ASL-users 18 years old with computer and internet access participated online; 100 (70

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high, 30 low education) and 50 (35 high, 15 low education) were randomized to the bilingual and monolingual modalities. Modalities provide virtually identical content on creating a family tree, using the family tree to identify inherited cancer risk factors, understanding how cancer predisposition can be inherited, and the role of genetic counseling and testing for prevention or treatment. 25 True/False items assessed knowledge; a Likert scale item assessed confidence. Data were collected within 2 weeks before and after viewing the information.

**Results**—Significant interaction of language modality, education, and change in knowledge scores was observed (p=.01). High education group increased knowledge regardless of modality (Bilingual: p<.001; d=.56; Monolingual: p<.001; d=1.08). Low education group increased knowledge with bilingual (p<.001; d=.85), but not monolingual (p=.79; d=.08) modality. Bilingual modality yielded greater confidence creating a family tree (p=.03).

**Conclusions**—Bilingual approach provides a better opportunity for lower educated Deaf ASL-users to access cancer genetics information than a monolingual approach.

## Keywords

health disparities; health education; genetic counseling; sign language; deaf

## INTRODUCTION

Cancer disparities are widening among subpopulations differing by literacy level, race/ethnicity, language, and other characteristics (1), underscoring the need for culturally and linguistically appropriate cancer health communications. One subpopulation in need of appropriate cancer health communications is the US Deaf community (2), for whom American Sign Language (ASL) is the primary language. General information about some cancers exists for this community (2-8). However, up to 10% of cancers occur due to a genetic alteration in a high risk gene, which increases the chance of developing cancer and can affect medical management(9) in ways that could lead to cancer screening (10-12) and prevention (13, 14). Access to cancer genetics education is important because it increases genetics knowledge and understanding of factors involved in assessing risk for cancer and possible options (15, 16). However, no materials exist for Deaf ASL-users on this topic although, in the absence of research, there is no expectation that the prevalence of cancers with a strong genetic component differs between deaf and hearing populations. This study addresses the need for appropriate cancer genetics healthcare information for the Deaf community.

Health information in spoken or print English does not satisfactorily address Deaf ASL-users needs. Language acquisition background for deaf individuals is varied (17), and as a result, their English reading comprehension level tends to be lower on average (18, 19) than the average 7th-8th grade reading level in the general US population(20). Moreover, most health information is written at even higher grade levels (1) and without attention to cultural aspects of the Deaf community, a particularly important deficit when addressing the sensitive topic of genetics (21-24).

Increasing awareness of the need for effective access to health information has led to development of cancer prevention educational programs for the Deaf community. Though none have addressed genetic predispositions, efforts that address language-concordance by accounting for ASL as the first language for many deaf individuals have been found to increase their knowledge regarding a variety of cancers (3-8, 25, 26) and to promote cancer screening behaviors (6). Although conveying health information in ASL is key, these efforts also have included visual images and graphics and English language elements such as captioning or English text. These elements take into account the considerable linguistic variation in the Deaf community, ranging from use of ASL to more English-ordered signed form, and that many deaf people routinely communicate using a bilingual approach and visual modality (27). A bilingual approach allows for ASL information provision and inclusion of English medical terminology using text and fingerspelling, which can facilitate understanding and later information recall (28-30).

Though a bilingual approach is important, education level has not adequately been taken into account in the design of health information for the Deaf community. This is a significant oversight because education level, English reading literacy, and ASL proficiency are interrelated (19, 31, 32), suggesting that a more nuanced approach is needed. Since the 2013 American Community Survey[1] found that ~50% of the US population with a hearing disability (defined as "person is deaf or has serious difficulty hearing") aged 21-64 has high school or less education (33), the absence of education level in tailoring health information may result in a failure to identify and address the health education needs of a significant proportion of this population, likely the Deaf community members at greatest risk for lacking adequate health knowledge.

This randomized study compares the effectiveness of cancer genetics information presented in two modalities, a bilingual ASL with English closed captioning modality and a monolingual English text modality. We hypothesized that ASL-using Deaf adults randomly assigned to the bilingual modality would show greater knowledge gains compared with those randomized to the monolingual modality. We further hypothesized that education level would significantly interact with language modality.

## METHODS

A parallel 2:1 randomized controlled study design was used, with education as a stratification factor. Before study enrollment began, the statistician prepared a block randomization scheme via excel macro where participant assignments were made within an education level by sampling from a randomly allocated block of size *3 to 15* without replacement. The routine masked block size and upcoming assignments from the study coordinator who implemented it. The statistician was blinded to subject assignment. Low education was defined as high school diploma or less education; high education as some college or more education.

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[1] www.disabilitystatistics.org. Click on American Community Survey >Educational Attainment > Disability Type {Hearing Disability} > Education {less than a High School education}. The percentage of this group is 17.6%. Repeat for Education {a high school diploma or equivalent}. The percentage of this group is 32.3%.

## Study Sample

Inclusion criteria were: 18 years, deaf or hard-of-hearing (by self-report), ASL-user, and computer and internet access. Individuals unable to complete an online ASL Grammar Judgment Task-Revised (TGJASL-R, a measure of ASL syntactic competency) (34, 35) within one week were excluded, serving as an additional mechanism to determine if a participant had access to a computer and the internet and was sufficiently computer literate to take part in the study.

Participants were recruited nationally, November 2013-May 2014, via deaf clubs, organizations, community events, and a previous genetic counseling and testing study (36). Recruitment materials described an online study focused on learning about family health history and were disseminated in ASL or English text via study website (deafgeneticsproject.org), Facebook, video blogs, and advertisements.

After initial eligibility determination, prospective participants received a link to the TGJASL-R assessment. Those who completed this assessment within one week were randomized, regardless of their TGJASL score, to receive either the intervention [bilingual modality] or the control [monolingual modality] materials. Blinded to study group assignment, participants had two weeks to complete an online pre-test survey assessing demographic, primary and secondary outcome variables. They then received a link to the intervention or control educational materials. After viewing the assigned materials, participants had two weeks to complete the online post-test survey. All demographic, pre-test, and post-test surveys items were translated into ASL using a translation-back translation procedure (37, 38) and provided by video along with English text. Individuals completed the study online at a location of their choosing and received a $40 gift card upon completion. If an individual did not have a computer, but lived in Los Angeles, arrangements were made to meet with the study coordinator in a public place where a study laptop was provided. Follow-up was completed in June 2014. This study was approved with waiver of written consent by the institutional review boards at the University of California, Los Angeles and Gallaudet University, in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000.

## Conditions

**Intervention [Bilingual modality]: ASL with closed captioning**—Content and format were developed with feedback from Deaf individuals and study consultants using focus groups, pilot testing, and individual comments. The material was designed to encourage a proactive approach to understanding, documenting, and analyzing one's family health history, and is organized into six modules (videos; available at aslcancergenetics.org). The "Introduction" explains that although the focus is on hereditary breast, ovarian, uterine, and colon cancers, the information provided is applicable to other hereditary diseases. The remainder is delivered as a storytelling narrative, where viewers are introduced to Anna, a fictional character concerned about her risk for inherited breast cancer. The viewer learns more about basic cancer genetic concepts, while following Anna as she ascertains her cancer risk. For example, Anna creates her family tree in the module titled "Creating a Family

Tree," which explains how to document family health history. The module "Risk Factors for Inherited Cancer" identifies what to look for in a family tree that would suggest risk for genetic predisposition to cancer; "How Cancer is Inherited" focuses on genes and autosomal dominant inheritance of predisposition to cancer; "Role of Genetic Counseling and Testing" explains genetic counseling and testing, including the purpose, benefits, and possible outcomes of genetic testing for cancer predisposition; the "Review" module briefly reviews the previous modules. Two to four quiz items are included in four of the modules.

An ASL-specific narrative discourse delivered by a Deaf, male, native signer is the main presentation strategy. In this style, a narrator visually presents information using space, head movements, eye gaze, facial expression, and body position (39). Visual aids, text, and closed captioning supported the ASL discourse. Graphics appear to the narrator's right or at full screen. Closed captioning is placed at the bottom of the screen and is turned on (default), with option to turn off. Quizzes, three different camera angles, and multi-sequence editing were used to keep the audience visually engaged (40). Total video running time is 37.3 minutes.

**Control [Monolingual modality]: English text—**The monolingual modality provides information in written English and features the same six modules, quizzes, and graphics used in the bilingual modality (available at aslcancergenetics.org). The English text was developed from the bilingual modality's closed captioning text. Because word-for-word translation from ASL to English is not possible, the text was modified to fit a stand-alone English text format. To facilitate computer screen reading, information was provided in small segments (41) of 1-7 short paragraphs and no more than one graphic per page. This resulted in 38 short, simple, web pages. Assuming 200 words per minute reading speed for an average reader at $6^{th}$-$7^{th}$ grade level (42), expected viewing time is 19.0 minutes. The text's Flesch-Kincaid (FK) grade level (43) is 6.8; and the FK reading ease score (44) is 64.8, considered standard English level and estimated at $7^{th}$-$8^{th}$ grade level (45).

### Measures

**Primary Outcome—**Twenty-five true/false items assessed knowledge of cancer genetics (17 items) and genetic counseling (8 items) (Appendix Table A). Currently, no validated cancer genetics knowledge survey is available in ASL. Therefore, we used items from existing cancer genetics knowledge questionnaires (46, 47) and developed additional items to address the content. Pre- and post-test knowledge scores (number of correct responses; theoretical range 0-25) were computed for each participant. Higher scores indicate greater number of correct responses.

**Secondary Outcomes—**Secondary outcomes, assessed at pre- and post-test, evaluated the extent to which the material empowered participants to develop their family health history and utilize genetics healthcare (Appendix Table A). At post-test, general satisfaction, perceived usefulness, amount of new information provided, preference for language modality, and amount of attention paid to the signing and/or closed captioning (intervention only) also were assessed (Appendix Table A). Item responses are dichotomized for analyses

(shown in Appendix Table A), with the exception of the item assessing amount of new information, which is treated as a quantitative variable.

## Statistical Analyses

Participants were analyzed in the group to which they were assigned even if it could be ascertained that they did not view the educational materials. Individual missing knowledge items were treated as incorrect (7, 48); however, total knowledge scores were treated as missing if all items on the genetics or genetic counseling subscale were missing. Baseline characteristics were compared between the language modality groups. Between-group analyses were performed using t-tests for quantitative measures and Chi-square/Fisher's Exact tests for categorical measures. Repeated measures regression analysis using SAS PROC MIXED examined the effects of language modality (bilingual, monolingual), education level (high, low) and time (pre-test, post-test) on our primary outcome, knowledge scores. This statistical procedure allows for data collected at only one time point to be included in the analysis. The model included main effects, 2-way interactions and the 3-way interaction capturing the combined effects of language modality and education on knowledge score change. Within-group analyses used paired t-tests or McNemar's test for quantitative or dichotomous variables, respectively. Cohen's d statistic (49) was computed as a measure of effect size for between-group and within-group differences on quantitative variables. Absolute differences with 95% CI were computed for between-group and within-group comparisons on dichotomous variables. Analyses were performed using SAS v9.4 (50). Tests were 2-tailed and statistical significance was set at $\alpha$=.05. No adjustments for multiple comparisons were made, hence examination of secondary outcomes is considered exploratory.

Sample size was determined using a fixed effects ANOVA model, 50:50 high:low education group ratio, published effect sizes(16), and pilot data suggesting a larger effect of genetic counseling on genetics knowledge of individuals with lower education. Under these conditions, our initially planned 1:1 bilingual:monolingual randomization scheme with n=25 individuals per language modality/education group (total n=100) had 80% power to detect Cohen's d effect size .24 with two-sided p-value=.05.

## RESULTS

Figure 1 depicts study and sample flow. To accommodate additional bilingual modality investigation, we increased sample size from 100 to 150. Due to greater-than-anticipated recruitment challenges, the high:low education group ratio was changed from 50:50 to 70:30. We obtained no data on 2/150 (1.3%) participants at pre-test and 4/150 (2.67%) participants at post-test (Figure 1). The two individuals who dropped out after randomization were unaware of their group assignment. We obtained complete primary outcome data on 85.3% and 86.7% of the sample at pre- and post-test, respectively, and filled in missing data on 12.7% and 8.6% participants at pre- and post-test. Knowledge scores at only a single assessment timepoint were available on six participants due to missing all data on at least one knowledge subscale at the other time point. Primary outcome analysis is based on 148 participants with 290 out of 300 (96.7%) possible pre- and post-test observations. There was

no evidence that participants with missing pre- or post-test observations were associated with group assignment or demographic variables. Language modality groups did not differ in sample characteristics (Table 1).

Education level was not associated with amount of time spent viewing the bilingual (t=−.25, p=.80, d=.06) or monolingual materials (t=.77, p=.44, d=.24). However, scores on TGJASL-R and self-rated ease with reading English were higher in the high education group (TGJASL-R M=.79, 95% CI .77-.82; English reading ease M=8.7, 95% CI 8.3-8.9) than the low education group (TGJASL-R M=.64, 95% CI .60-.68, p<.001, d=1.15; English reading ease M=6.8, 95% CI 6.2-7.4, p<.001, d=1.12).

### Primary Outcome

At pre-test, participants assigned to the bilingual and monolingual modalities correctly answered on average 73.9% (18.5/25) and 72.2% (18.1/25) of the knowledge items, and at post-test, 82.2% (20.6/25) and 81.6% (20.4/25), respectively. Repeated measures regression analysis found that scores were higher at post-test ($F(1,138)=37.95$, $p<.001$) and for the high education group ($F(1,144)=38.07$, $p<.001$) but did not differ by language modality ($F(1,144)=.80$, $p=.37$). However, the combination of language modality and education level affected knowledge score change ($F(2,138)=4.33$, p=.01; Figure 2). Knowledge score increased for the bilingual modality/low education group (M=2.55, 95% CI 1.41-3.7, t=4.57, p<.001, d=.85) but not for the monolingual modality/low education group (M=.25, 95% CI −1.76-2.26, t=.27, p=.79, d=.08). Knowledge scores increased for the bilingual modality/high education and monolingual modality/high education groups (M=1.9, 95% CI 1.07-2.72, t=4.58, p<.001, d=.56; M=3.0, 95% CI 2.03-4.0, t=6.31, p<.001, d=1.08, respectively).

### Secondary Outcomes

At pre-test, the intervention and control groups did not significantly differ in terms of intentions to develop a family health history or utilize genetics healthcare (Table 2). At post-test, these groups did not differ in terms of confidence to start a conversation with family about cancer history or intention to discuss their family history with a health care provider or genetic counselor (Table 2). However, those exposed to the bilingual modality were more likely than those exposed to the monolingual modality at post-test to feel 'very confident' developing their family tree (p=.03), and to report a 'definite' intention to see a genetic counselor upon a doctor's recommendation (p=.002), a 'definite' intention to have cancer genetic testing upon a doctor's recommendation (p=.02), and a 'definite' intention to encourage a friend or family member to seek genetic counseling for cancer risk (p=.001) (Table 2). Moreover, the percentage of participants exposed to the bilingual modality who reported feeling 'very confident' to develop their family tree and who 'definitely' intended to encourage friends or family members to seek genetic counseling for cancer risk significantly increased compared to pre-test (p=.005, p=.003, respectively), whereas this was not the case for participants exposed to the monolingual modality (Table 2).

At post-test, there was no significant difference between language modalities in mean rating of amount of new information provided in the educational material (bilingual: M=68.5, 95% CI 62.2-74.8; monolingual: M=61.8, 95% CI 52.1-71.6; p=.24, d=.21). Moreover, both

groups endorsed that the modules explained things in understandable terms; that the information was 'very useful'; that answering module quiz questions was not annoying; and that the modules were not too long (Table 3). However, compared to the monolingual modality, those exposed to the bilingual modality were more likely to report that they 'liked' the format (p<.0001), were 'very satisfied' with the modules (p=.04), and that they would 'definitely' recommend the educational modules to their family and friends (p=.03) (Table 3). Of those exposed to the bilingual modality, 95.7% indicated that the ASL speed was good, and 73.1% indicated that they focused their attention on both the signer and the closed captioning, while 19.4% focused most of their attention on the signer only, and 7.5% on the closed captioning only.

## DISCUSSION

This randomized study addresses, for the first time, approaches to effectively bring non face-to-face cancer genetic information to a wide range of Deaf adult ASL-users. When comparing the effectiveness of the bilingual and monolingual approaches without regard for educational level, there was no evidence that they differed in their ability to enhance ASL-users' cancer genetics knowledge. However, when taking education into account, significant differences in knowledge gains were found. Deaf individuals with some college or more education experienced knowledge gains regardless of language modality. Deaf individuals with high school or less education exposed to the bilingual modality also experienced knowledge gains. However, despite spending as much time reviewing the monolingual educational materials as the higher education group, those with high school or less education received no benefit in terms of increased understanding. Because ~50% of the US deaf/hard-of-hearing population has a high school or less education (33) this highlights the importance of providing health information using a bilingual approach, especially when the materials are targeted to all members of the Deaf community. As this intervention was evaluated with Deaf adult male and female ASL-users of different ethnic/racial groups, education levels, and ASL proficiency, the results indicate that a wide range of Deaf adult ASL-users would benefit from viewing the bilingual cancer genetics education modules for increasing their cancer genetics knowledge, with the goal of preventing cancer.

Although health knowledge may be necessary to reduce health disparities, individuals must ultimately take action to promote good health outcomes. Given the association between uptake of preventive health services among Deaf ASL-users and language-concordance with face-to-face peer-educators (6) and in the clinical setting (51), we were eager to identify the type of non-face-to-face communication that most likely would promote action. We found that language-concordant health information provided in ASL within the framework of a bilingual approach resulted in benefits such as greater confidence in developing a family tree, intention to see a genetic counselor or have cancer genetic testing upon a doctor's recommendation, intention to encourage others to seek genetic counseling for cancer risk, and recommending the health information to family and friends. The last finding is particularly important because of the importance of peer-to-peer information exchange in the Deaf community (52). Based on these findings we hypothesize that the bilingual approach will be more likely to lead to actions that would promote good health outcomes than a monolingual approach that offers non-language-concordant health information. Given the

evidence that this bilingual modality had a positive impact on cancer genetics knowledge, confidence, and intentions, the next step would be to evaluate whether those changes in knowledge result in health behaviors that result in good health outcomes.

The majority of those exposed to the bilingual modality reported that they focused their attention on both the signer and the closed captioning, validating the importance of a bilingual approach. Although no standards exist for implementing a bilingual approach, there also is no evidence that adapting existing video material developed for a hearing audience by embedding a window with a video of an interpreter signing the information with closed captioning (picture in picture) is an effective way to implement a bilingual approach (2). Rather, this study adds to the growing evidence that ASL-users' knowledge and satisfaction increases when materials are developed with Deaf community input, ASL discourse is the main point of reference, first-language users sign the material, and supplemental captioning and graphics are included (3-8).

Our findings also suggest that attention be paid to the audience's language proficiency and the material's complexity. The control condition's ~7th grade reading grade level conforms to the average US adult reading level (20) and to NIH guidelines for health information (53). Although this health information was of value to Deaf ASL-users with at least some college education, it was insufficient to increase cancer genetics knowledge for ASL-users with less education. Providing information in ASL with captioning and appropriate presentation format and discourse addressed this gap. The bilingual modality produced knowledge gains for the low education group despite their lower ASL grammar competency scores, suggesting that the material's ASL level was accessible to a range of ASL-users. Because there is no formal system yet for evaluating ASL grade level for educational materials, participant ASL grammar proficiency can be used as one means for examining the utility of ASL-based educational material.

### Limitations

First, we developed some knowledge items to provide content coverage, however, item reliability and validity were not tested. Both language modalities yielded knowledge gains for the high education group, suggesting that they provided comparable information and contained the requisite information on the concepts assessed. Second, English is the standard US language for disseminating health information. Therefore we compared the intervention with virtually identical content provided in written English at the general US reading grade level to simulate the real world experience of deaf individuals. Although factors other than reading level may have been present in the monolingual modality to bias results, both language modality groups endorsed that the modules provided new information, explained concepts in understandable terms, and were reasonable in length. These findings suggest that the conditions were comparable on factors beyond reading level and reduce the possibility of potential bias. Third, we assessed reading literacy via a self-reported confidence with reading English instead of an objective English reading comprehension test. We found that the mean self-reported English reading ease score for the higher education group was significantly higher than the mean score for the lower education group. This result is consistent with the finding that education is positively associated with reading

comprehension in a sample of deaf adults (19) using an objective measure of reading comprehension, thereby providing some support for the validity of our self-report measure. Fourth, because no adjustments for multiple comparisons were made, examination of secondary outcomes is considered exploratory. Finally, we developed web-based educational materials to reach as many individuals as possible. A limitation of our approach is that our results do not necessarily generalize to Deaf ASL-users who do not have a computer or internet access.

## Conclusions

Effective access to language-concordant preventive health information is an important step towards reducing health disparities. This study fills a gap in knowledge regarding the effectiveness of a bilingual approach for providing non face-to-face genetic information for Deaf individuals whose primary language is ASL. An online approach allows deaf people in any geographical area to access important genetic information. A bilingual format using ASL video clips with closed captioning options provides this population with full access in their preferred language with access to specific medical terminology in written English. More broadly, taking education and language into account can inform the design and evaluation of other health educational initiatives for the Deaf community.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

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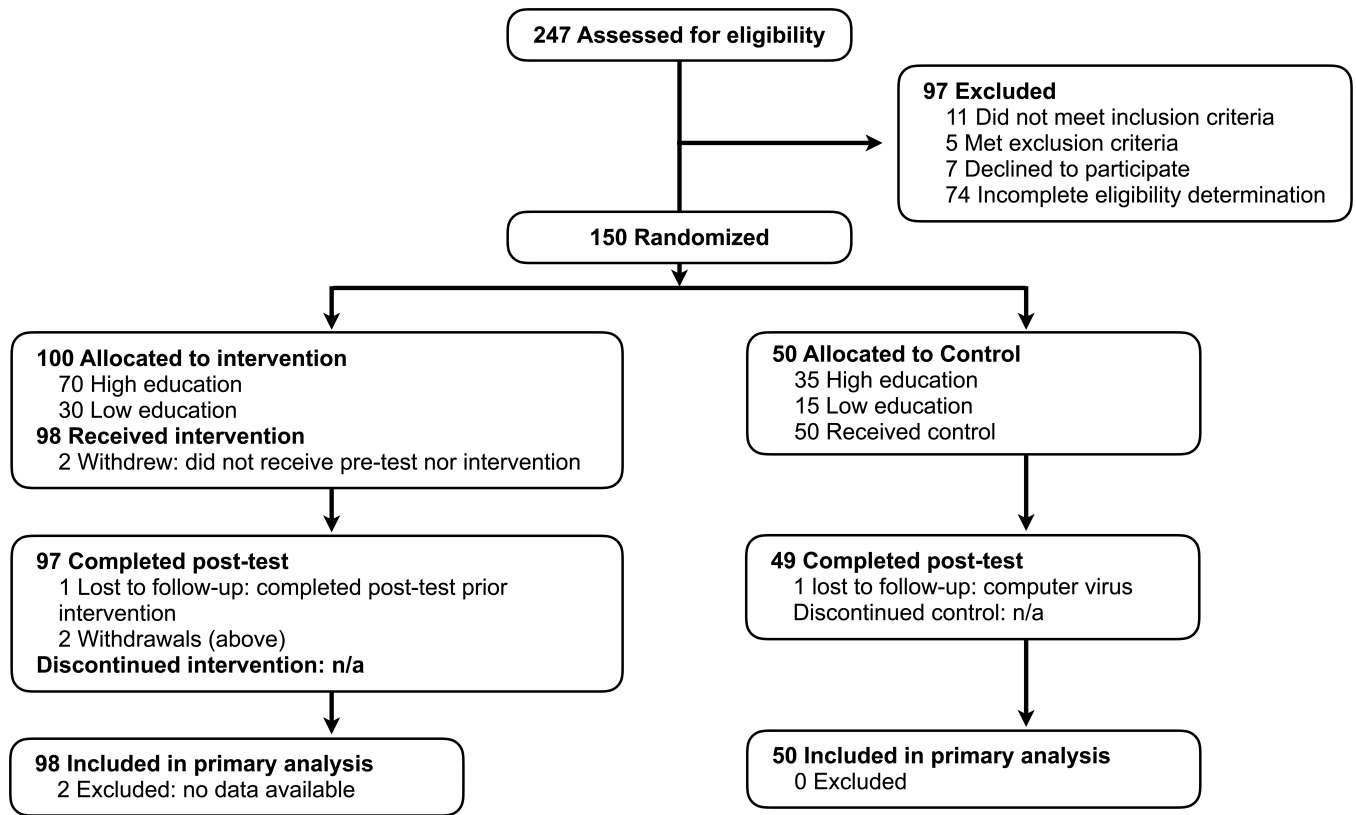
**Figure 1.**
Consort Flow Diagram for Deaf ASL-Users' Knowledge of Cancer Genetics Health
Information Study.

**Figure 2. Change in Least Square Estimates of the Total Knowledge Scores by Subgroups**
Least square estimates of the total knowledge scores (95% CI) from between-groups
repeated measures regression are plotted for each language modality, education group, and
assessment timepoint. 290 of 300 possible observations used in the analysis. CC = closed
captions; LSE = least squares estimate

**Table 1**

Sample Characteristics

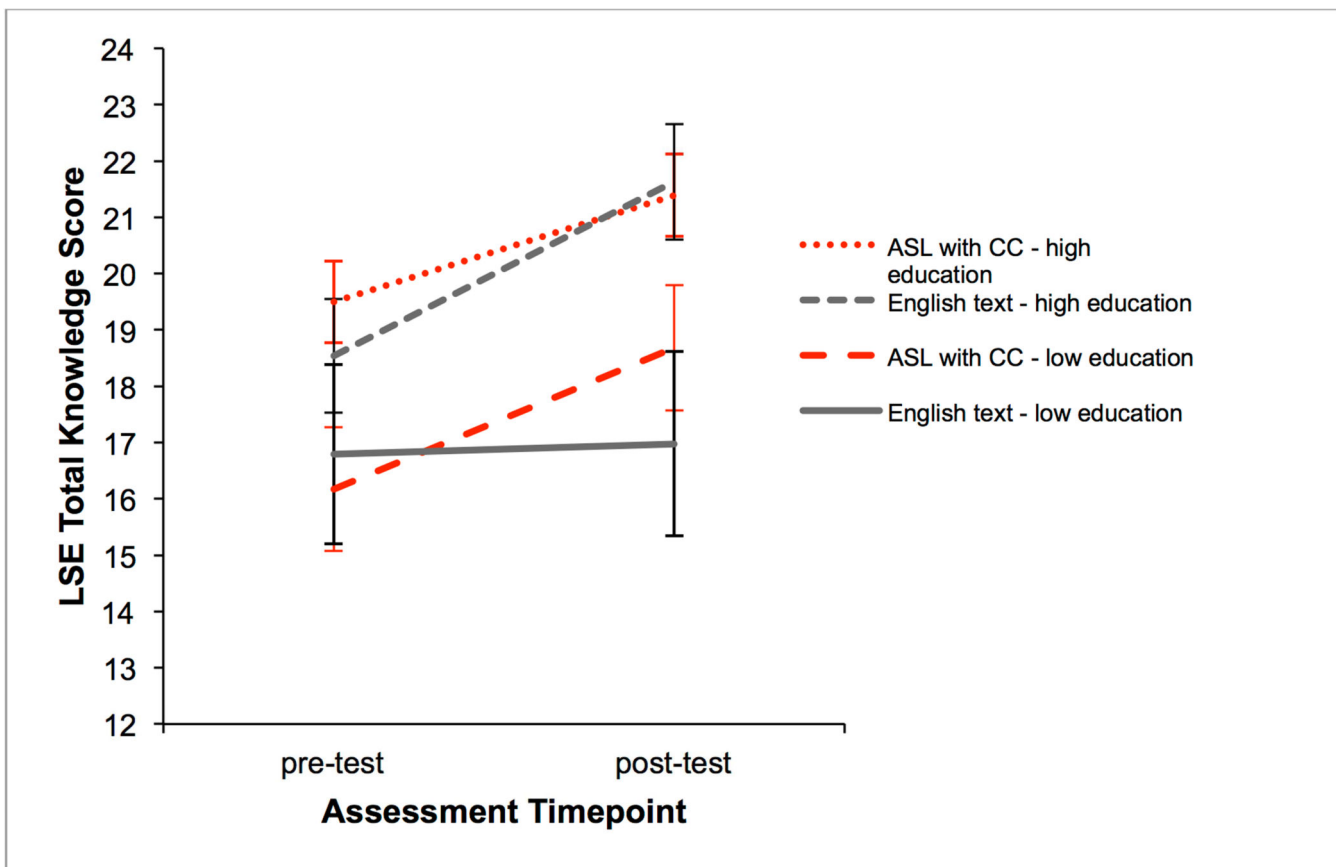| Characteristic | Intervention: Bilingual Modality[a] | Control: Monolingual Modality[a] | p |
|---|---|---|---|
| Sample size | 100 | 50 | |
| Deaf or hard-of-hearing, No. (%) | | | .11 |
| Deaf | 95 (95.0) | 44 (88.0) | |
| Hard-of-hearing | 4 (4.0) | 6 (12.0) | |
| Other[§] | 1 (10) | 0 (0) | |
| Primary communication mode with deaf individuals, No. (%) | | | |
| ASL | 95 (95.0) | 47 (94.0) | 1.0 |
| PSE, SEE, SIM-COM | 13 (13.0) | 9 (18.0) | 1.0 |
| Orally | 1 (10) | 0 (0) | .47 |
| In writing | 2 (2.0) | 0 (0) | .55 |
| Age, M (SD), years | 44.5 (14.7) | 44.6 (12.5) | .97 |
| Female, No. (%) | 60/100 (60) | 35/50 (70) | .28 |
| High school diploma or less, No. (%) | 30/100 (30) | 15/50 (30) | 1.0 |
| Ethnicity/Race, No. (%) | | | .58 |
| Non-Hispanic Caucasian | 64/96 (66.7) | 26/49 (53.1) | |
| Hispanic | 18/96 (18.8) | 13/49 (26.5) | |
| Asian | 6/96 (6.3) | 3/49 (6.1) | |
| Black | 4/96 (4.2) | 4/49 (8.2) | |
| Native American/American Indian | 1/96 (1.0) | 1/49 (2.0) | |
| Other | 3/96 (3.1) | 2/49 (4.1) | |
| Age became deaf, M (SD), years | 1.8 (1.6) | 1.5 (1.1) | .13 |
| Age began using ASL, M (SD), years | 7.7 (6.5) | 8.9 (8.8) | .39 |
| Cultural affiliation, No. (%) | | | .08 |
| Deaf community | 59/98 (60.2) | 25/48 (52.1) | |
| Deaf and Hearing communities | 30/98 (39.8) | 20/48 (41.7) | |
| Hearing community | 0 | 1/48 (2.1) | |

| Characteristic | Intervention: Bilingual Modality[a] | Control: Monolingual Modality[a] | p |
|---|---|---|---|
| Neither community | 0 | 2/48 (4.2) | |
| Type of High school attended[†], No. (%) | | | .68 |
| Deaf-based | 55/98 (56.1) | 24/47 (52.2) | |
| Mainstream | 17/98 (17.4) | 12/47 (26.1) | |
| Mixed | 14/98 (14.3) | 5/47 (10.9) | |
| Hearing-based | 12/98 (12.2) | 5/47 (10.9) | |
| At least one deaf relative, No. (%) | 51/100 (51) | 20/50 (40) | .23 |
| Personal/family history of cancer[‡], No. (%) | 57/98 (58.2) | 25/50 (50) | .60 |
| Current student, No. (%) | 15/98 (15.3) | 3/48 (6.3) | .18 |
| Prior genetic counseling or testing[#], No. (%) | 40/98 (40.8) | 19/50 (38) | .86 |
| Pre-test knowledge score, M (SD) | 18.5 (3.3) | 18.1 (3.2) | .47 |
| TGJASL–R score[§], M (SD) | 0.76 (0.15) | 0.73 (0.16) | .34 |
| Understand fingerspelling[*], M (SD) | 8.2 (1.9) | 8.0 (2.1) | .59 |
| Read English well[*], M (SD) | 8.0 (1.9) | 8.3 (2.0) | .39 |
| Time between pre-test survey and viewing materials, M (SD), days | 5.2 (6.4) | 4.7 (7.0) | .60 |
| Time between viewing materials and post-test survey, M (SD), days | 0.4 (1.0) | 0.5 (1.5) | .69 |
| Time spent viewing materials, M (SD), minutes | 48.3 (18.3) | 25.1 (16) | n/a |

¥ Participant response was "oral deaf"

[†] Hearing-based high schools predominantly provide oral instruction in the classroom, i.e., oral school for the deaf, or a public school without interpreter/support services; Deaf-based high schools predominantly provide signed instruction (ASL or coded communication) in the classroom; Mainstream highschools captures public schools that predominantly provide sign instruction (ASL or coded communication) with interpreter/support services; Mixed high schools is defined as attending two or more of the previously described high school programs

[‡] breast, ovarian, or colon cancer

[#] includes participation in Deaf Genetics Project

[§] TGJASL-R: ASL Grammar Judgement Task. >0.5-1 reflects increasing grammatical accuracy; 0.5 reflects random guessing; <0.5 reflects systematic bias

[*] self-rated on scale of 0 (low) – 10 (high)

**Table 2**

Within-Group and Between-Group Analyses of Secondary Outcomes

| | Within-Group Comparisons | | | | | | | | Between-Group Comparisons | | | |
| | Intervention: Bilingual Modality | | | | Control: Monolingual Modality | | | | Pre | | Post | |
| Item | Pre | Post | AD[‡] (95% CI) | p | Pre | Post | AD (95% CI) | p | AD (95% CI) | p | AD (95% CI) | p |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Very confident developing family tree | 28.9 (28/97) | 43.7 (42/96) | 13.6 (4.6, 22.7) | .005 | 22.9 (11/48) | 24.5 (12/49) | 0 (−14.4, 14.4) | 1.0 | 5.95 (−8.9, 2.1) | .55 | 19.3 (3.7, 34.9) | .03 |
| Very confident starting a conversation with family about health history | 41.7 (40/96) | 46.9 (45/96) | 5.3 (−5.4, 15.9) | .34 | 43.8 (21/48) | 55.1 (27/49) | 10.6 (−1.4, 22.8) | .09 | −2.1 (−19.2, 15.1) | .86 | −8.2 (−25.4, 8.9) | .38 |
| Intend to discuss family history with health care provider or genetic counselor | 54.6 (53/97) | 51.6 (49/95) | −2.1 (−13.4, 9.3) | .72 | 57.1 (28/49) | 51.1 (24/47) | −6.4 (−22.3, 9.7) | .44 | −2.5 (−19.5, 14.5) | .86 | .52 (−17.0, 18.0) | 1.0 |
| Intend to see a genetic counselor upon a doctor's recommendation | 51.1 (48/94) | 54.7 (52/95) | 1.1 (−9.1, 11.3) | .83 | 38.8 (19/49) | 26.5 (13/49) | −10.4 (−23.6, 2.8) | .13 | 12.3 (−4.7, 29.4) | .22 | 28.2 (12.3, 44.1) | .002 |
| Intend to have cancer genetic testing upon a doctor's recommendation | 53.1 (51/96) | 57.3 (55/96) | 3.2 (−7.5, 13.9) | .56 | 42.9 (21/49) | 36.7 (18/49) | −4.2 (−15.6, 7.3) | .48 | 10.3 (−6.8, 27.4) | .29 | 20.6 (3.8, 37.3) | .02 |
| Intend to encourage friend or family member to seek genetic counseling for cancer risk | 32.6 (31/95) | 51.0 (49/96) | 17.0 (6.6, 27.5) | .003 | 24.5 (12/49) | 22.5 (11/49) | −2.1 (−12.8, 8.7) | .71 | 8.1 (−7.2, 23.4) | .34 | 28.6 (13.2, 43.9) | .001 |

[‡]AD = absolute difference

**Table 3**

Between-Group Analyses of Opinions about Language Modality

| Item | Intervention: Bilingual Modality % (No.) | Control: Monolingual Modality % (No.) | AD[‡] (95% CI) | p |
|---|---|---|---|---|
| Liked the format of the educational modules | 84.9 (79/93) | 47.7 (21/44) | 37.2 (20.8, 53.7) | <.0001 |
| Very satisfied with the educational modules | 78.6 (70/89) | 61.4 (27/44) | 17.3 (.57, 34.0) | .04 |
| Very useful information in the educational modules | 77.7 (73/94) | 61.7 (29/47) | 15.9 (−.29, 32.2) | .07 |
| Definitely recommend educational modules to family or friends | 55.3 (52/94) | 34.1 (15/44) | 21.2 (4.0, 38.5) | .03 |
| Educational module explained things in understandable terms | 91.6 (87/95) | 85.4 (41/48) | 6.2 (−5.3, 17.6) | .26 |
| Not annoying to answer the quiz questions in the educational module | 86.3 (82/95) | 81.3 (39/48) | 5.1 (−7.9, 18.1) | .47 |
| Educational modules not too long | 68.4 (65/95) | 70.8 (34/48) | −2.4 (−18.3, 13.5) | .85 |

[‡]AD = absolute difference