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Linguistic Validation of Interactive Educational Interventions in NeuroTrauma

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Abstract

Background—Neurological surgeons oftentimes educate patients and their families on complex medical conditions and treatment options. Time constraints and varied linguistic and cultural backgrounds limit the amount of information that can be disbursed.

Objective—To assess the linguistic validity of interactive educational interventions in non-English speaking traumatic brain injury (TBI) and concussion patients.

Methods—273 English, Spanish, Korean, and Vietnamese speaking neurotrauma patients (1) completed a pre-survey to evaluate incipient understanding, (2) interacted with an iPad-based iBook (Apple) on concussion or TBI in their native language, (3) completed a post-survey to gauge changes in understanding, then (4) consulted their neurosurgeon.

Results—All subjects (124 patients and 149 family members) significantly increased (95% confidence [CI], $p \ll 0.01$) in post-survey scores (average pre-iBook score: 2.810 vs. post-iBook score: 4.109), regardless of native language or cultural background. Caucasian participants scored significantly higher than the combination of all ethnicities on both the baseline (95% CI, $p < 0.01$) and the post-iBook surveys (95% CI, $p < 0.01$), while Asian participants scored significantly lower (85% CI, $p < 0.05$) than the combination regardless of similar baseline scores.

Conclusions—Interactive iBook-based interventions on concussion and TBI enhanced (1) patient comprehension, (2) comfort with their medical condition and follow-up care, and (3)

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improved communication between the patient and the physician. These findings are linguistically valid irrespective of participants' native language or cultural background.

Keywords

concussion; education; iBook; neurological surgery; brain injury; culture; language

Introduction

Traumatic Brain Injury (TBI) is a prevalent societal problem with a yearly incidence of 2.5 million individuals, and an annual cost of $60 billion in medical expenses and productivity losses in the United States alone.[12345] A variety of etiological contributors can lead to TBI, hence patients present with an assortment of neurological deficits that require careful examination, diagnosis, and intervention by their physician(s).[678910] Even minor head injuries, such as a concussion (usually categorized by a Glasgow Coma Scale score of 13-15), can lead to multitudes of psychophysiological defects that present immediately or sometime after the insult. Repeated concussions are potentially linked to severe neurodegenerative disorders, particularly chronic traumatic encephalopathy.[11121314]

Neurological surgeons are challenged with the important responsibility of treating TBIs, which, alongside surgical and medical interventions, entails educating patients and their families on the spectrum of TBI, any surgical interventions performed, the recovery process, and preventative measures to reduce further damage.[15161718] The implementation of pedagogical interventions, such as promotion of helmets and protective equipment to youth, or simple tips to prevent falling of the elderly, may help prevent further injury and repeat TBI or concussion.[192021]

Interactive and easy-to-read educational materials that engage patients and their family members can facilitate active-learning, knowledge acquisition, and long-term information retention in a variety of clinical and non-clinical locations.[222324] Furthermore, comparisons to text-based educational material have demonstrated the advantages of active electronic educational interventions in both pre- and post-operative settings, specifically in the field of neurotrauma.[25262728293031]

A variety of factors, including inadequate information, lack of time, linguistic barriers, and varied cultural backgrounds of patients limit the amount of knowledge that can be disbursed by the physician, and lead to suboptimal patient education through any medium.[3233] Although the efficacy of interactive educational interventions, such as educational iBook modules presented on an iPad (Apple), has been demonstrated in English speaking patients of all ages who are familiar with such technologies, the linguistic validity of this intervention has not yet been investigated. Herein we assess the linguistic validity of interactive educational interventions in non-English speaking TBI and concussion patients in comparison to native English-speakers [Figure 1]. We hypothesize that interactive presentation of information in the outpatient settings will improve self-reported patient knowledge and help optimize the patient-physician interaction.

Materials and Methods

English, Spanish, Korean, and Vietnamese speaking patients and accompanying family attending the corresponding author's American College of Surgeons verified Level I Trauma Center from August 2015 to June 2017 consented to participate in this Institutional Review Board approved study. Following consent, subjects received a pre-survey to evaluate incipient understanding regarding their medical condition, treatment options, and follow-up care. Surveys are scored on a 5-point Likert scale, with scores closer to 5 indicating higher self-reported knowledge [Supplemental Digital Content 1].[34] Then, participants received a standard 32GB Apple® iPad (Apple Inc., Cupertino, CA) displaying an interactive iBook on (1) TBI or (2) concussion depending on the patient's clinical diagnosis [Figure 2].[353637]

Patients were seen 2 weeks to 6 months following their initial injury to ensure that all had recovered considerably, as indicated by Glasgow Outcome Scores (GOS) of 5.[38] Patients who presented with distinct injuries on their computed tomography (CT) scans upon admission received information on TBI. Head injuries implicated on CT scans included skull fractures, subarachnoid hemorrhages, diffuse axonal injuries, traumatic contusions, subdural hematomas, and epidural hematomas. Some TBI patients had received operative procedures (e.g. brain monitoring or craniotomies), however only those that recovered to a GOS of 5 prior to their clinic visit were included in this study. Concussed patients had normal CT scans, but were clinically diagnosed with concussion. Accompanying family members were also provided with the same educational content given to the patient.

All electronic modules were synthesized using *iBooks Author* software and were presented in the patients' native language. Synthesized information focuses on head injury prevention, management, prognosis, and treatment, all written at a 10^{th} grade level based on the Coleman-Liau Index.[39] Patients took roughly 10 minutes to completely read the iBook, which consists of interactive diagrams, videos, and pop-out widgets. While participants reviewed the educational information, researchers were asked to leave the room in order to diminish bias. Afterwards, subjects were provided with a Likert-scale post-survey to gauge any changes in their understanding of head injury. Lastly, patients and family members underwent a standard clinical encounter with their neurosurgeon.

Both surveys were also provided in the patients' native language, with some surveys consisting of not only knowledge questions, but also communication and comfort questions to allow internal measures of assessing response reliability. Surveys and iBooks were initially crafted in English and then meticulously translated via the five-step process detailed by Forsyth et. al.: (1) professional translation, (2) extensive review by bilingual consultants, (3) initial revisions by bilingual consultant, (4) evaluation by non-patient bilingual participants, and (5) final review and revision by bilingual consultants.[40]

A randomly selected group of subjects (n = 121) were asked to complete the aforementioned extended surveys for internal survey reliability testing, and for assessing self-perceived utility of the iBook.[41] Survey data were analyzed using statistical toolboxes of IBM SPSS Statistics and MATLAB® R2017a. Specifically, the Alpha Model of Reliability Analysis subscale in SPSS (IBM, Armonk, NY) allowed for the calculation of Cronbach's reliability

coefficient, alpha, and ttest(x,y), ttest2(x,y), or anova1(x)/multcompare(s) MATLAB (Mathworks, Natick, MA) functions were used to perform paired t-test, unpaired t-test, or oneway analysis of variance (ANOVA) respectively.

Results

Of the 273 subjects who participated in the study, 156 (57%) patients and family members viewed iBooks in English, 70 (26%) in Spanish, 26 (9%) in Vietnamese, and 21 (8%) in Korean. Cronbach's alpha reliability was calculated via the validation questions found on the extended surveys (alpha > 0.750). Paired t-test analysis of pre- and post-survey responses at 95% confidence was tabulated; all subjects significantly improved in post-survey scores ($p \ll 0.01$ for all) regardless of native language [Figure 3; Table 1]. One-way ANOVA comparison of different languages at 95% confidence interval indicated that English iBook participants scored (2.894 pre-survey and 4.241 post-survey) similar to Korean participants (3.086 pre-survey and 4.095 post-survey), but significantly higher than Spanish participants (2.663 pre-survey and 4.000 post-survey), Vietnamese participants (2.485 pre-survey and 3.623 post-survey) and the Combined average of all languages (2.810 pre-survey and 4.109 post-survey) on the post-survey ($p < 0.05$ for all). Despite scoring higher on the post-survey, English subjects had a similar pre-survey score to every language with the exception of Vietnamese, whose participants scored significantly lower than English and Korean subjects on the pre-survey ($p < 0.05$). Vietnamese participants also scored significantly lower than every language, including the Combined average of all languages, on the post-survey ($p < 0.01$ for all), regardless of scoring similar to Spanish participants and the Combined average on the pre-survey.

Furthermore, paired t-test analysis of subject responses showed significant improvement regardless of cultural/ethnic background as well ($p \ll 0.01$ for all) [Figure 4; Table 2]. Caucasian participants scored (3.148 pre-survey and 4.336 post-survey) significantly higher than Hispanic/Latino participants (2.671 pre-survey and 4.106 post-survey), Asian participants (2.771 pre-survey and 3.933 post-survey), and the combination of all ethnicities (2.810 pre-survey and 4.109 post-survey) on both the pre- and post-surveys ($p < 0.01$ for all). Although Caucasian subjects also scored higher than the Others category (combination of African-Americans, Native-Americans, and Middle-Easterners [2.733 pre-survey and 4.080 post-survey]), this difference was not statistically significant due to large variances in ANOVA. Lastly, Asian participants scored significantly lower than the combination of all ethnicities ($p = 0.0156$) despite of similar baseline scores on the pre-survey.

Discussion

Interpreted Results and Past Experience

As evidenced, after reading interactive educational iBooks all participants significantly improved on self-reported knowledge and perceived understanding of their disease regardless of native vernacular or ethnicity. The pre- and post-surveys administered in this study were synthesized using statistical software and a random set (n = 121) consist of multiple question-clusters, thus allowing for analysis of internal consistency, validity, and reliability of participant response with Cronbach's alpha calculation (alpha > 0.750 in this

study).[41] Additionally, previous work by our institution had demonstrated significant differences in self-reported knowledge following an iBook-based educational intervention as opposed to a simple static pamphlet containing identical information.[29] Not only did patients' self-reported knowledge increase significantly more through the use of interactive iBooks, but participants that received the iBook scored their experience with the educational information significantly higher than those who received pamphlets (4.65/5.00 iBook vs. 4.27/5.00 pamphlet, $p \ll 0.01$ at 95% CI).[2930] Additionally, this trend was validated in participants both old and young.[30] The results presented in this manuscript elaborate on our previous work[293031] by focusing on and demonstrating the cross-cultural and linguistic validity of interactive educational interventions.

Superiority of interactive electronic education in healthcare, as indicated by our previous work, is correlated with results from various other studies both inside and outside of clinical settings.[252627284243444546] Accordingly, observation of similar outcomes in a more diverse and cross-cultural patient population was foreseen. Discrepancies in pre- and post-survey scores between various languages and ethnicities, such as Vietnamese-speakers scoring lower than Korean- and English-speakers on the pre-survey ($p = 0.00896$ and 0.0167 respectively) or Asian participants scoring lower than combined average of all ethnicities ($p = 0.0156$), were also expected as inherent outcomes due to complex connotations, nuances, and differential word mapping amid each language.[4748] Additionally, translation of pedagogic iBooks and questionnaire surveys may not have been comprehended as intended due to dissimilar syntax, diction, tone, and content-context relationship found between languages and cultures.[4950]

Our adopted team-based approach sought to diminish innate obstacles to translation of questioners as elaborated by Forsyth et. al., yet we observed anomalies.[40] Vietnamese-speaking patients scored significantly lower than every individual language, and the combination of all languages, on the post-survey ($p < 0.01$ for all) regardless of comparable incipient understanding indicated by similar pre-survey scores to Spanish-speakers and combination of all languages. Initial investigation of the educational backgrounds of participants did not elucidate any reason for this problem, as there was no correlation with the educational backgrounds of participants and the performance of the language [Figure 5]. This observation correlates with our previous studies and is supported by the fact that all survey and iBook material were written at a 10^{th} grade educational level. Educational backgrounds did not significantly influence any self-reported gain in knowledge.[3139] Additionally, attribution of Caucasians' higher performance on the post-survey as compared to almost every language, and even the combination of all languages ($p < 0.01$ for all), could simply be due to the fact that they started with a higher initial knowledge on the subject matter as indicated by their also significantly higher pre-survey scores ($p < 0.01$ for all). It is also plausible that Caucasians are more adept at using technology than other ethnicities, and they learned more from their interaction with the iBook. This phenomenon of ethnicity discriminant technology literacy has previously been observed in literature, and can also be attributed to higher socioeconomic status.[51]

Limitations and Barriers to Entry

A major barrier to entry is associated costs in hundreds to thousands of dollars, depending on scale, that accompany the purchasing of hardware (iPads or tablets), programming of software (iBooks or eBooks), synthesizing of surveys, hiring of personnel for administration, and safe-keeping of tablets, surveys, and other materials (such as consent forms).[29,30,31] These barriers might pose as a greater obstacle in underserved communities and in 3rd world countries with potential high costs of imported electronics.[52]

Although surveys properly tested patients' self-reported improvements in understanding of their condition, no efforts were made to assess long-term retention of knowledge through patient follow up, or through future visits. Furthermore, although surveys synthesized by our statistician contained constructs and question-clusters to allow assessments of patient response reliability (Cronbach's alpha > 0.750), there was no objective means of truly gauging patient honesty in their responses, thus surveys may still be subject to slight self-reporting bias.

Conclusion

Interactive iBook-based interventions on concussion and TBI enhanced (1) patient comprehension, (2) increased patients' comfort with their medical condition and related follow-up care, and (3) improved communication between the patient and the physician. These findings are linguistically valid irrespective of participants' native language or cultural background, and help alleviate educational hurdles faced by physicians.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

TBI	Traumatic Brain Injury
CI	Confidence Interval
GOS	Glasgow Outcome Score
CT	Computed Tomography

Highlights

- Neurological surgeons must educate patients and their families on complex medicalconditions and surgical treatment options. Time constraints, linguistic hurdles, and variedcultural backgrounds of patients limit the amount of information that can be disbursed,which may lead to suboptimal patient education.
- Interactive iBook-based interventions on concussion and TBI enhanced (1) patientcomprehension, (2) comfort with their medical condition and follow-up care, and (3)improved communication between the patient and the physician.
- These findings are linguistically valid irrespective of participants' native language orcultural background, thus removing educational hurdles faced by physicians.

Figure 1.

Screenshots of the English (left) and Vietnamese (right) Concussion iBooks depicting integration of video content, pop-up and scrolling widgets, as well as interactive image galleries.

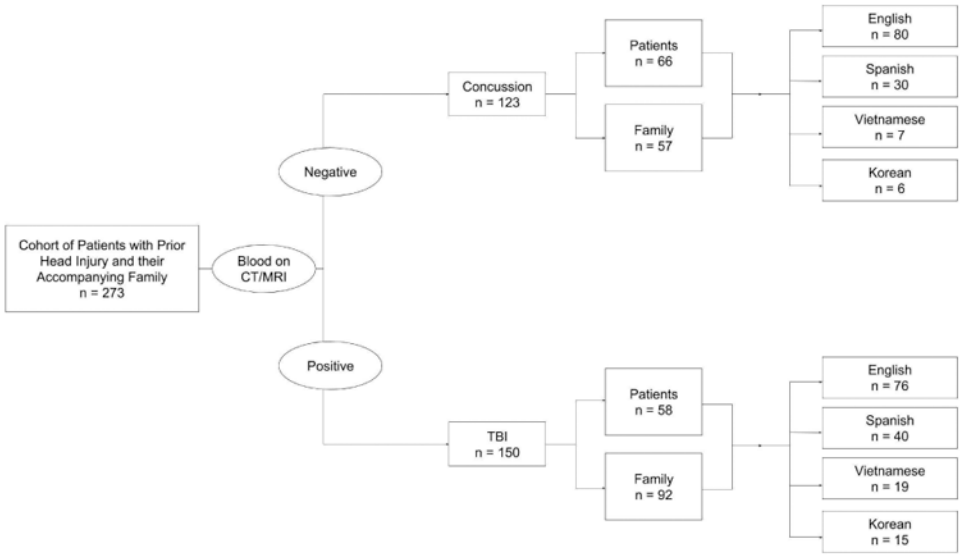

Figure 2.
Flow chart depicting the diagnostic classification of participants in the study.

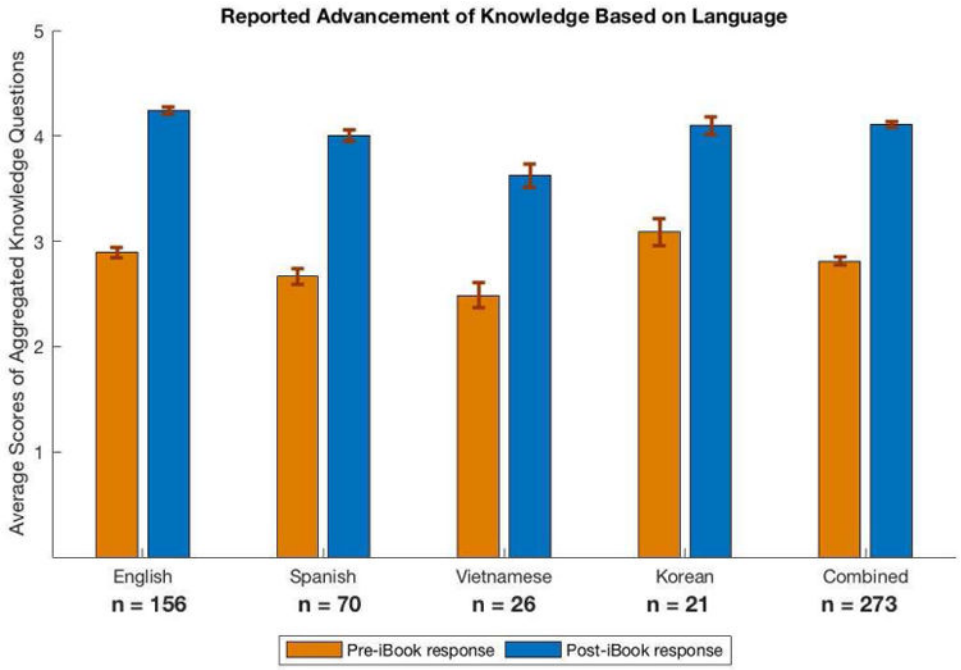

Figure 3.

Paired T-test analysis of averaged pre- and post-survey scores of subjects stratified by language demonstrating significant improvement in post-survey score in all groups (95% confidence interval, p = 1.87e-133, 3.83e-64, 1.21e-13, 9.58e-22, and 3.12e-221 respectively as shown in the plot from left to right).

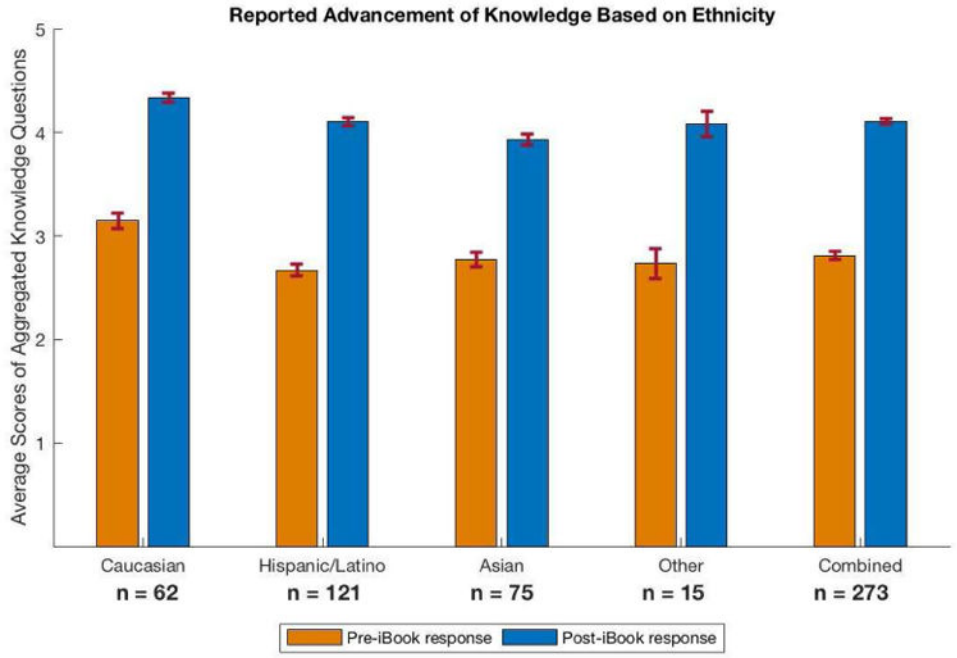

Figure 4.

Paired T-test analysis of averaged pre- and post-survey scores of subjects stratified by ethnicity demonstrating significant improvement in post-survey score in all groups (95% confidence interval, p = 4.22e-48, 5.22e-113, 9.28e-51, 1.46e-16, and 3.12e-221 respectively as shown in the plot from left to right).

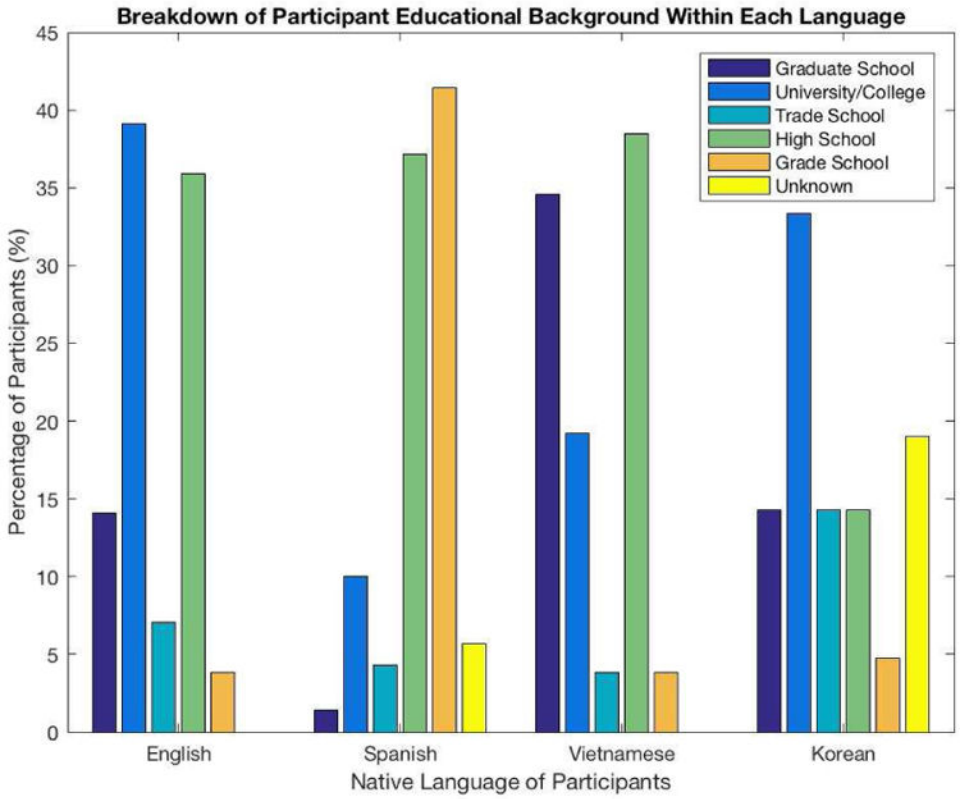

Figure 5.

Although some groups, namely English- and Korean-speaking patients, seem to have higher proportions of Graduate School and University educated participants, there is no clear correlation between such occurrences and pre- or post-survey scores found if Figures 3. For example, Spanish-speaking subjects have a much higher proportion of Grade School participants, lower proportions of College educated participants, and similar proportions of High School participants to Vietnamese-speaking subjects, yet they scored significantly higher than Vietnamese-speakers and not significantly different from other languages on the post-survey. Percentages are as follows: (English: 14.1%, 39.1%, 7.05%, 35.9%, 3.85%, 0%; Spanish: 1.43%, 10.0%, 4.29%, 37.1%, 41.4%, 5.71%; Vietnamese: 34.6%, 19.2%, 3.85%, 38.5%, 3.85%, 0%; Korean: 14.3%, 33.3%, 14.3%, 14.3%, 4.76%, 19.0% respectively as the order of bars in the graph from left to right).

Table 1

Language breakdown of surveys collected from patients in outpatient settings.

Language	N = 273		Average Pre-survey score (combined)	Average Post-survey score (combined)
	Patients	Family		
Korean	11	10	3.086	4.095 *
Vietnamese	11	15	2.485	3.623 * †
Spanish	26	44	2.663	4.000 *
English	76	80	2.894	4.241 * †
All Languages	124	149	2.810	4.109 *

* Indicates statistically significant improvement in the post-survey score ($p \ll 0.01$ for all).

† Indicates significantly different score from the combined average of all languages ($p < 0.05$).

No language had a significantly higher score than the combined average of all languages.

Table 2

Ethnic breakdown of surveys collected from patients in outpatient settings.

Ethnicity	N = 273		Average Pre-survey score (combined)	Average Post-survey score (combined)
	Patients	Family		
Other	5	10	2.733	4.080 *
Asian	35	40	2.771	3.933 *†
Caucasian	27	35	3.148‡	4.336 *†
Hispanic/Latino	51	78	2.671	4.106 *
All Ethnicities	124	149	2.810	4.109 *

* Indicates statistically significant improvement in the post-survey score ($p \ll 0.01$ for all).

† Indicates significantly different score from the combined average of all ethnicities ($p < 0.05$).

‡ Indicates significantly higher score from the combined average of all ethnicities ($p < 0.01$).