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Interactive eBooks in Educating Patients and their Families About Head Injury Regardless of Age

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Abstract

Objectives—Traumatic Brain Injury (TBI) is a common and debilitating injury that is particularly prevalent in patients over 60. Given the influence of head injury on dementia (and vice versa), and the increased likelihood of ground-level falls, elderly patients are vulnerable to TBI. Educational interventions can increase knowledge and influence preventative activity to decrease the likelihood of further TBI. We sought to determine the efficacy of interactive tablet-based educational interventions in elderly patients on self-reported knowledge.

Patients and Methods—Patients and family members, ages 20–90, presenting to a NeuroTrauma clinic completed a pre-survey to assess baseline TBI or concussion knowledge, depending on their diagnosis. Participants then received an interactive electronic book (eBook), or a text-based pamphlet with identical information, and completed a post-survey to test interim knowledge improvement.

Results—All participants (n = 180), regardless of age, had significantly higher post-survey scores (p<.01, 95% CI). Elderly participants who received the eBook (n=39) scored lower than their younger counterparts despite higher pre-survey scores (p<0.01, 95% CI). All participants who received the eBook (n=20, 90) significantly improved on the post-survey (p<0.01, 95% CI) when compared to participants who received the paper pamphlets (n=10, 31). All participants significantly preferred the eBook (p<0.01, 95% CI).

Conclusions—We demonstrated that interactive educational interventions are effective in the elderly TBI population. Enhanced educational awareness in the elderly population, especially patients at risk or with prior TBI, may prevent further head injury by educating patients on the

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Declaration of Interest

The authors report no declarations of interest.

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importance of avoiding further head injury and taking precautionary measures to decrease the likelihood of further injury.

Keywords

concussion; TBI; traumatic brain injury; iBook; education; neurosurgery; age; elderly

Introduction

Traumatic Brain Injury (TBI) is one of the leading causes of death and the leading cause of disability in the United States, costing \$9.2 billion in lifetime medical bills and \$51.2 billion in annual productivity loss.¹ Multiple head injuries, such as concussions, may result in cumulative neuropsychological deficits. Specifically, military veterans, football players, boxers, and other athletes who have suffered repeated head trauma, even asymptomatic subconcussive hits, have been found to develop a form of progressive tauopathy called chronic traumatic encephalopathy (CTE).² CTE and other forms of trauma induced neurodegeneration manifest in later adult life as alterations in higher cognitive abilities, learning, psychological disorders, and even dementia or Alzheimer's disease (AD).^{3,4,5,6} Furthermore, individuals over the age of 75 have the highest rates of TBI-related hospitalization and death.

One of the most effective methods to reduce the prevalence of TBI and concussion is taking precautionary measures to reduce the likelihood of head injury, in particular, through improved public education and awareness.⁷ Injury prevention is particularly important in those who have already suffered some form of head trauma, for any head injury increases sensitivity and the risk of receiving future TBIs.⁸ As mentioned, individuals also bear a higher risk of suffering another TBI or concussion once they have had their first injury.^{9,10}

Despite the benefits of patient education in preventing and mitigating illness, patients, particularly those with brain injuries, may have difficulties comprehending their medical condition and any associated medical or surgical interventions. This can be exacerbated in individuals with Alzheimer's disease (AD) or cognitive alterations.¹¹ Furthermore, individuals with cognitive decline, as in AD, are at an increased risk of developing a TBI or concussion, and thus this patient population can uniquely benefit from enhanced educational interventions.¹⁸ Interactive educational tools have been shown to be particularly useful in enhancing learning, especially when compared to passive learning through static informational sources.^{12,13,14} Based on previously reported literature supporting the benefits of interactive learning tools, we developed an interactive and user-friendly electronic book (eBook) to educate patients on neurotrauma, namely concussion and TBI [Figure 1].¹⁵ In particular, we wanted to examine the effects of age on knowledge acquisition, in order to determine whether educational eBooks are effective in patients older than 60 years of age. Furthermore, we wanted to determine the impact, if any, of a patient's pathology on their knowledge acquisition.

Patients and Methods

This study followed regulations set forth by the Institutional Review Board (IRB) at the University of California, Irvine Medical Center (UCIMC), an American College of Surgeons verified Level 1 Trauma Center. Upon consent, subjects were presented with a 5-question Likert scale pre-survey to assess baseline knowledge of their medical condition and future course of action. Following completion of the pre-survey, subjects were randomized to receive either an eBook pre-loaded on a standard 32GB Apple® iPad (Apple Inc., Cupertino, CA), or a paper pamphlet with the same information presented in text format.¹⁶¹⁷ The randomization process consisted providing eBooks to patients presenting to the first clinic day of the week, while pamphlets were provided to patients presenting to the second clinic day in that same week. One of two eBooks, or pamphlets, on (1) concussion or (2) TBI was provided based on the patient's diagnosis [Figure 2]. All patients had Glasgow Outcome Scores of 1, and presented from 2 weeks – 6 months following their initial injury. TBI patients had distinct lesions visualized on their admission head CT scans that included diffuse axonal injury, subarachnoid hemorrhage, traumatic contusions, skull fractures, epidural hematomas, and subdural hematomas. Patients who underwent operative procedures (e.g. brain monitoring or craniotomies) had recovered to GOS of 1 at the time of the visit. Concussed patients had normal CT scans and a clinical diagnosis of concussion. The majority of the patients had been evaluated and treated for their head injury at UCIs' trauma center. A small number of patients had been treated at another facility and referred specifically to the UCI NeuroTrauma clinic.

Each eBook was created using free *iBooks Author* software provided by Apple®, and consisted of several interactive chapters with built-in educational videos, pop-up and scrolling widgets, photo galleries, and interactive images. The information focused on head injury prevention, management, and prognosis. It is written at a 10th grade level based on the Coleman-Liau Index, and takes approximately 10 minutes to completely read.¹⁸ The paper pamphlets contained verbatim the same informational material in a static text format.

Patients were asked to view the material and were then presented with a 5-question Likert scale post-survey to assess provisional improvement in understanding of their disease and self-reported knowledge [Supplementary Content 1]. Lastly, patients and family members met with their neurosurgeon and underwent a standard clinical encounter, which included discussions about traumatic brain injury and review of pertinent radiologic studies.

A randomly selected subset of the participants (n = 101) were chosen to complete an extended survey consisting of additional question categories, which queried subjects' self-reported experience with the eBook or pamphlet, as well as their comfort and confidence with their condition. The summated rating scale created from the aggregation of multiple category extended surveys allowed for internal consistency testing, determining participant response reliability, as well as eBook utility.¹⁹

Data analysis was carried out with two mathematical programs. Specifically, Cronbach's reliability coefficient, alpha, was tabulated using built-in Alpha Model of Reliability

Analysis subscale in IBM SPSS Statistics, and paired or unpaired t-tests were performed via $ttest(x,y)$ or $ttest2(x,y)$ MATLAB® R2016a respectively.²⁴

Results

86 patients and 94 family members completed the surveys ($n = 121$ younger than 60, $n = 59$ older than or equal to 60). 51 of the participants received an informational pamphlet instead of the eBook. Patients and family members 60 years of age and over who received the eBook scored an average of 3.12 (out of a total of 5) on the pre-survey and significantly improved to an average score of 4.10 on the post-survey ($P = 2.07e-22$). Similarly, patients under the age of 60 who received the eBook scored an average of 2.87 on the pre-survey and significantly improved to 4.42 on the post-survey ($P = 3.17e-93$) [Figure 3a]. Likewise, patients and family members 60 years of age and over who received the pamphlet scored an average of 2.73 on the pre-survey and significantly improved to an average score of 4.15 on the post-survey ($P = 7.22e-17$), and those under the age of 60 who were presented with the pamphlet scored an average of 2.88 on the pre-survey and significantly improved to 4.05 on the post-survey ($P = 2.20e-31$) [Figure 3b].

In order to determine the internal reliability and validity of the eBook survey scores, the Cronbach's reliability coefficient, alpha, was determined. Patient responses were proven reliable ($\alpha > 0.9$), suggesting that our surveys were valid measures of self-reported knowledge. Although both older and younger subjects in both groups statistically improved in their own post-survey scores, older participants scored significantly lower than younger controls after viewing neurotrauma eBooks, despite having higher pre-survey scores ($P = 3.56e-5$ and 0.0403 respectively) [Figure 3a]. This trend was noted within both TBI and Concussion eBooks ($P = 2.45e-3$ and $1.17e-2$ respectively). Older participants that read the neurotrauma pamphlets however did not score significantly different from their younger counterparts in either the pre- or post-surveys [Figure 3b]. Further investigation of pamphlets showed a reverse of the trend to be true in older patients that read the TBI and Concussion pamphlet, in which their pre-survey scores were significantly higher than younger patients in the TBI group but significantly lower than younger patients in the concussion group ($P = 1.03e-3$ and $7.00e-7$ respectively), while their post-survey scores were similar in both groups. The preceding data is summarized in [Table 1].

Examination of the discrepancy in eBook and pamphlet results indicated a significantly higher post-survey score in younger participants viewing the eBook ($P = 6.31e-6$), despite similar pre-survey scores to same age participants who read the pamphlets [Figure 3c]. Older participants viewing the eBook performed statistically similar to older individuals reading the pamphlets on the post-survey scores [Figure 3d].

Additional analysis of all participants older than 60 years of age indicated significantly lower pre- and post-survey scores for TBI patients as compared to their accompanying family members ($P = 2.87e-7$ and $1.36e-2$ respectively) [Figure 4a]. This, however, is not true for concussion patients, who scored similar to their family members in both pre- and post-surveys [Figure 4b]. Moreover, TBI patients averaged 2.51 on the pre-survey and 3.79

on the post survey, while concussion patients averaged a similar score of 2.87 on the pre-survey but scored significantly higher, 4.24, on the post-survey ($P = 4.79\text{e-}03$) [Figure 4c].

Although both eBooks and paper Pamphlets achieved similar objectives, patients significantly preferred the eBooks, giving them an average score of 4.65 as opposed to 4.27 for the pamphlets ($P = 1.35\text{e-}8$) [Figure 5]. Furthermore, older TBI participants and all younger subjects gained noticeably more knowledge from the eBooks than the printed pamphlets, indicated by a greater difference in their pre- and post-survey scores [Table 1]. This difference was reversed in the older concussion group, in which they improved more from the pamphlet than the eBook.

Discussion

Key results

Based on our findings, patients and family members older than 60 had significantly decreased post-survey performance when compared to their younger counterparts. This phenomenon is increased in subjects suffering neurotrauma, such as concussion or TBI. In particular, we found that neurotrauma patients over 60 years of age scored lower on the pre- and post-survey than family members of the same age. However, subjects in all age groups exhibited significantly improved performance on the post-survey, regardless of whether they were given an eBook or a paper pamphlet. Nonetheless, patients who received the eBook exhibited a significantly increased preference towards the eBook when asked about its potential helpfulness in a medical setting.

As mentioned, older TBI patients averaged 2.51 on the pre-survey and 3.79 on the post survey while concussion patients averaged a similar score 2.87 on the pre-survey but significantly higher score of 4.24 on the post-survey ($P = 4.79\text{e-}03$) [Figure 4]. This suggests that concussion patients perform better on baseline measures of knowledge than TBI patients. Furthermore, both TBI and concussion patients scored half a point lower than corresponding family members' averaged scores on all measures. This decrease in patient score suggests that individuals suffering from mild to severe forms of neurotrauma may have a significantly increased cognitive burden not shared by family members.

There is an interesting bidirectional influence of TBI and dementia. Not only is even a remote history of concussion or TBI a risk factor for the development of dementia, but also having dementia or AD increases the likelihood of having a head injury.²⁰²¹²²²³²⁴ Improved patient education is believed to equip patients and their family with knowledge and awareness that may decrease the likelihood of suffering a head injury. Our findings suggest that all neurotrauma patients, regardless of age or injury severity, benefit from educational intervention, with interactive tablet-based interventions surpassing static text-based resources in knowledge gains and self-reported perceptions of helpfulness. These findings are consistent with other studies, which have reported improved educational efficacy of interactive compared to static information disbursement modalities. In particular, younger subjects who received the eBook demonstrated significantly greater differences in pre and post-survey scores when compared to those receiving pamphlets ($P = 6.31\text{e-}5$), indicating enhanced knowledge gain from the eBook compared to the pamphlet [Figure 3c]. Elderly

patients did not score as high on the post-survey as their younger counter-parts, despite similar pre-survey scores, indicating a possible age effect on the utility of educational interventions in older patients [Figure 2]. This decrease in post-survey score is likely attributable to the potential novelty of the interactive eBook, since a similar trend was not noted in the control pamphlet group.

Limitations

Although efforts were made to examine the short-term retention of newly gained knowledge, we were unable to assess long-term knowledge retention, nor its impact on patient function or outcome. In general, patients were very enthusiastic and satisfied with the interactivity and additional information provided to them by the eBook. Ultimately, the seamless administration of an eBook-based educational intervention in the clinical setting may face several challenges, including the front-end tablet costs and eBook-creation efforts, as well as proper staffing to ensure patient procurement of the eBook-intervention. Furthermore, the survey measures used in this study were internally valid and reliable, as demonstrated by a Chronbach's alpha $>.9$, but these surveys may still be vulnerable to self-reporting bias and may not accurately reflect the subjects true knowledge. However, the improvements in patient knowledge and self-reported happiness with the intervention likely outweigh the implementation costs of this intervention.

It may also be argued that the concept of TBI may be different from concussion. The public has more exposure to concussion as it has been widely discussed in the media. The intricacies of TBI and the concepts of craniotomy or subdural hematoma are not widely known. Thus, this unfamiliarity may contribute to the lower scores with the TBI eBook compared to the concussion eBook.

Interpretation and Generalizability

The integration of tablet-based interactive educational modules in patient education warrants further investigation despite the multitude of implementation barriers previously discussed. Neurosurgeons are responsible for educating patients and their family members on the risks and benefits of their treatment options in an oftentimes time-constrained clinical visit. Even patients who have been discharged and are seen for follow-up have a 19.6% chance of rehospitalization within 30 days, partially due to a lack of fully understanding their discharge instructions or options for follow-up care.²⁵²⁶ Simply integrating tablet-based educational interventions prior to the patients' clinical encounter can significantly enhance patient reported knowledge levels of their medical condition and augment the patient-physician interaction. This can lead to more effective clinical care and enhanced patient satisfaction regardless of age or pathology.

Conclusion

Individuals 60 years or older scored significantly lower on the post-survey than their younger counterparts; however, the eBook was statistically beneficial in improving understanding of their medical condition and associated procedures or follow-up regardless of age. Additionally, the eBook was rated significantly higher as a helpful instructional tool

than control pamphlets. These findings held true in both patients and accompanying family members. Furthermore, patients with neurotrauma showed an improvement in understanding; however, it is not as robust as their family members, indicating that the eBook's effects may be attenuated in patients with a history of head injury.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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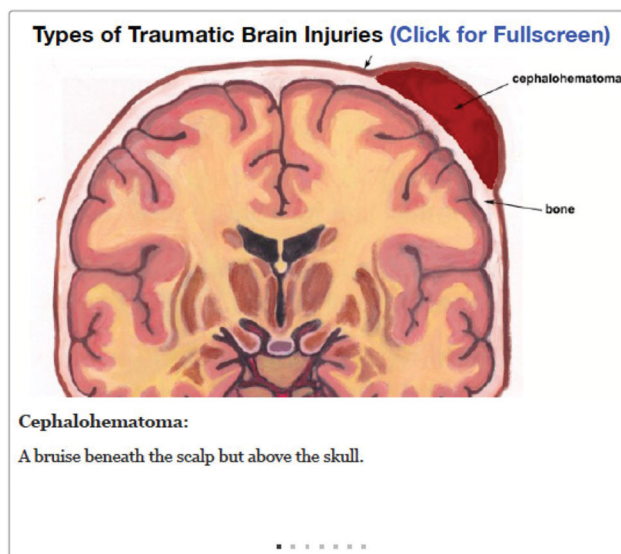
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Highlights

- Traumatic Brain Injury (TBI) is a common and debilitating injury that is particularly prevalent in patients over 60.
- Taking precautionary measures to reduce the likelihood of head injury can reduce the prevalence of TBI and concussion.
- We demonstrate that cost-effective interactive educational interventions are effective in the elderly TBI population.
- All participants preferred the interactive educational intervention over a standard paper pamphlet.

Other Brain Injuries



4

DOs and DON'Ts

- **DO** wear a helmet (bicycle, motorcycle, skateboard, etc.).
- **DO** wear your seat belt.
- **DO** ensure that children are secured in child safety seats.
- **DO** store firearms in locked cabinets with bullets in a separate location.
- **DO** wear protective headgear while playing sports.
- **DO** keep unsecured items off the floor and install safety features (non-slip bathtub mats, stairway handrails, etc.).
- **DO** exercise to increase strength and balance to avoid falls.
- **DON'T** drive under the influence of alcohol or drugs.
- **DON'T** engage in contact sports until cleared by your neurosurgeon.

10

Figure 1.
Screenshots of the TBI eBook.²³

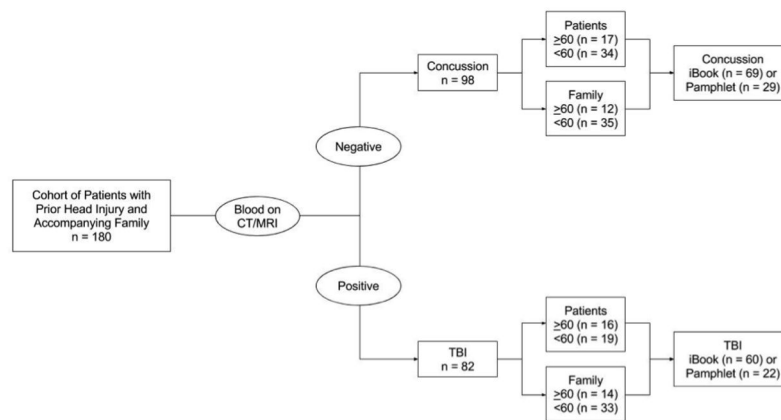
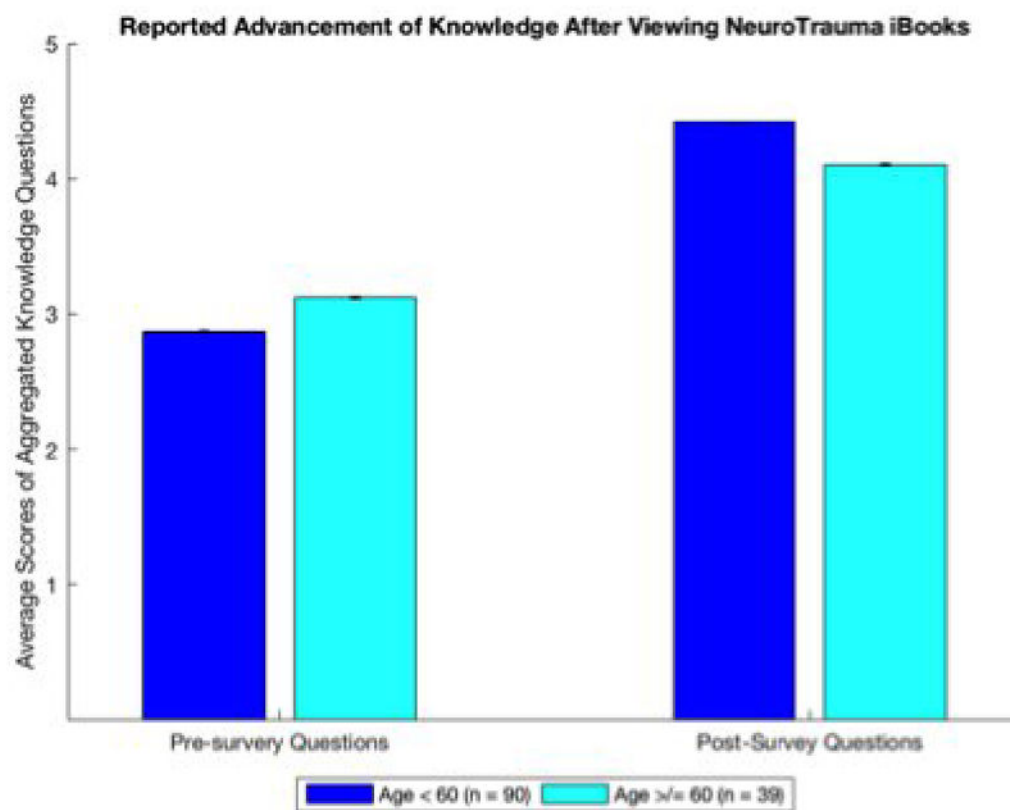
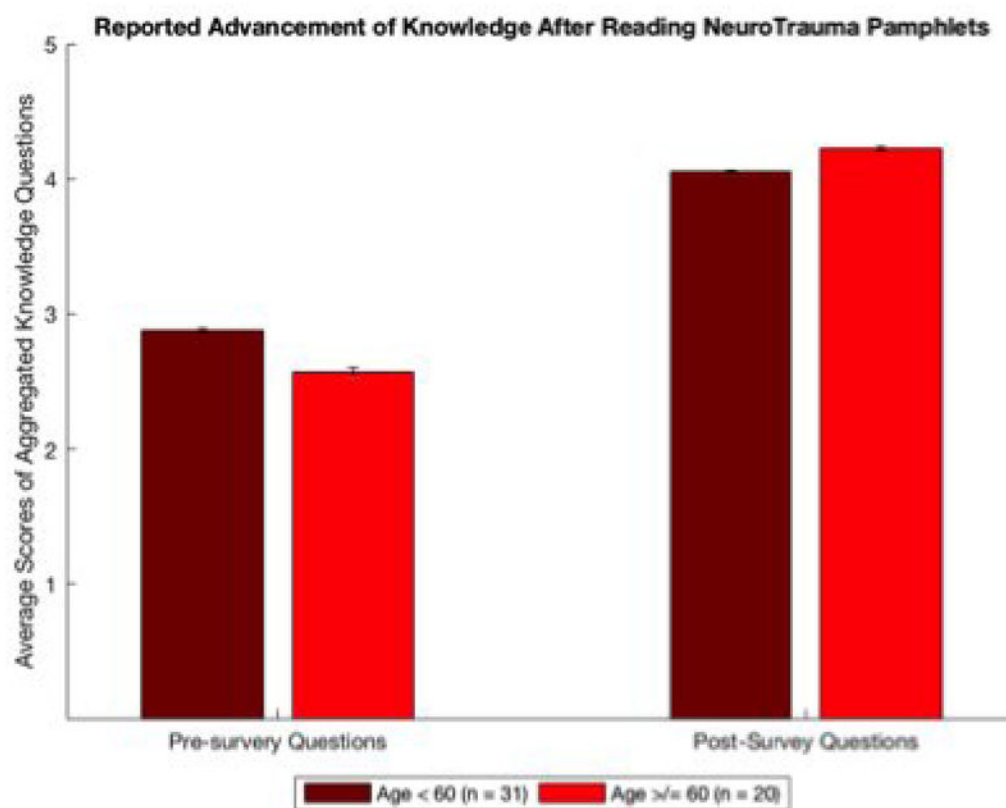
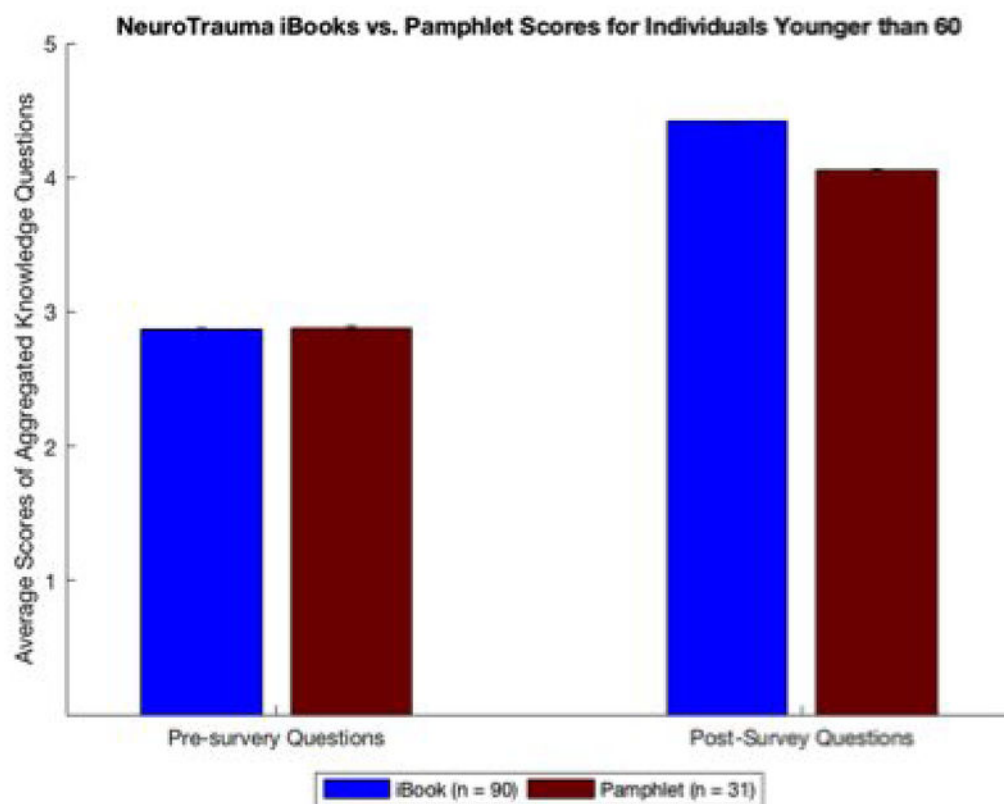


Figure 2.
Flow chart depicting the diagnostic classification of participants in the study.







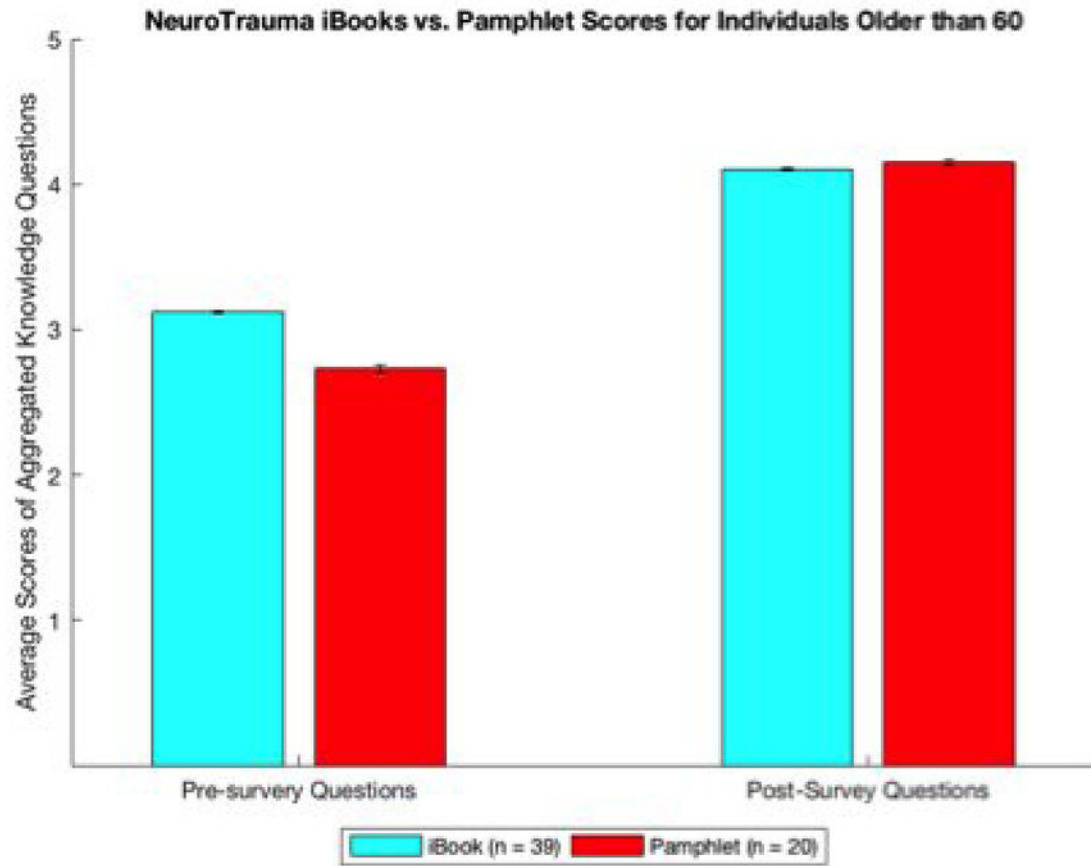
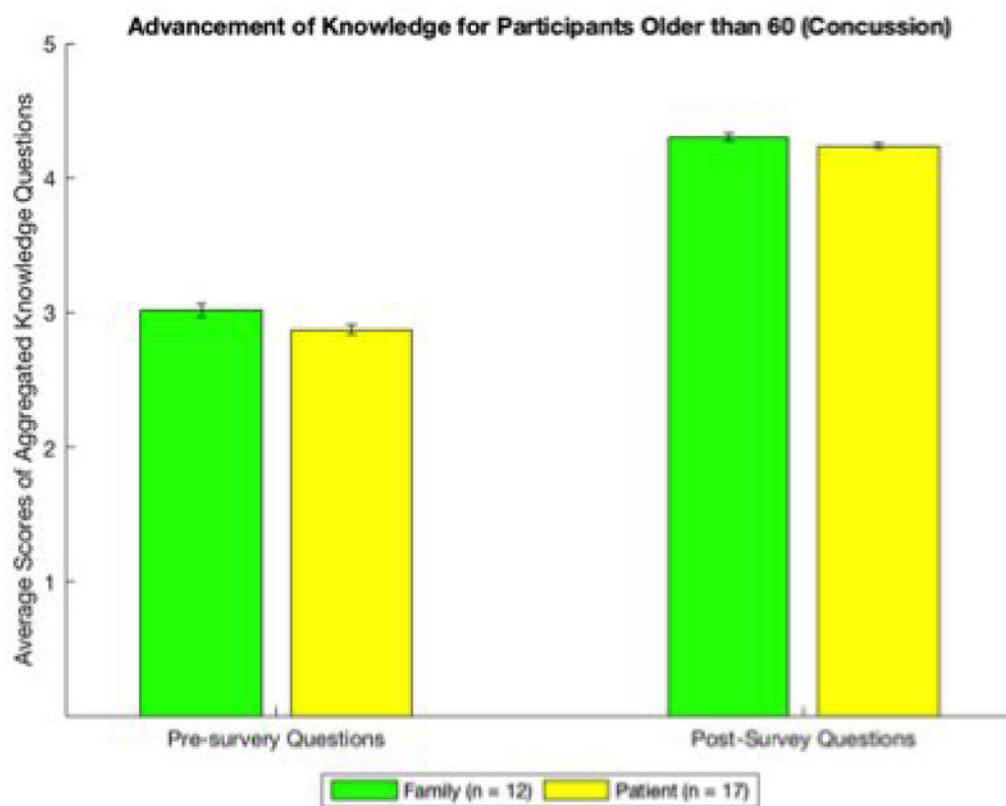
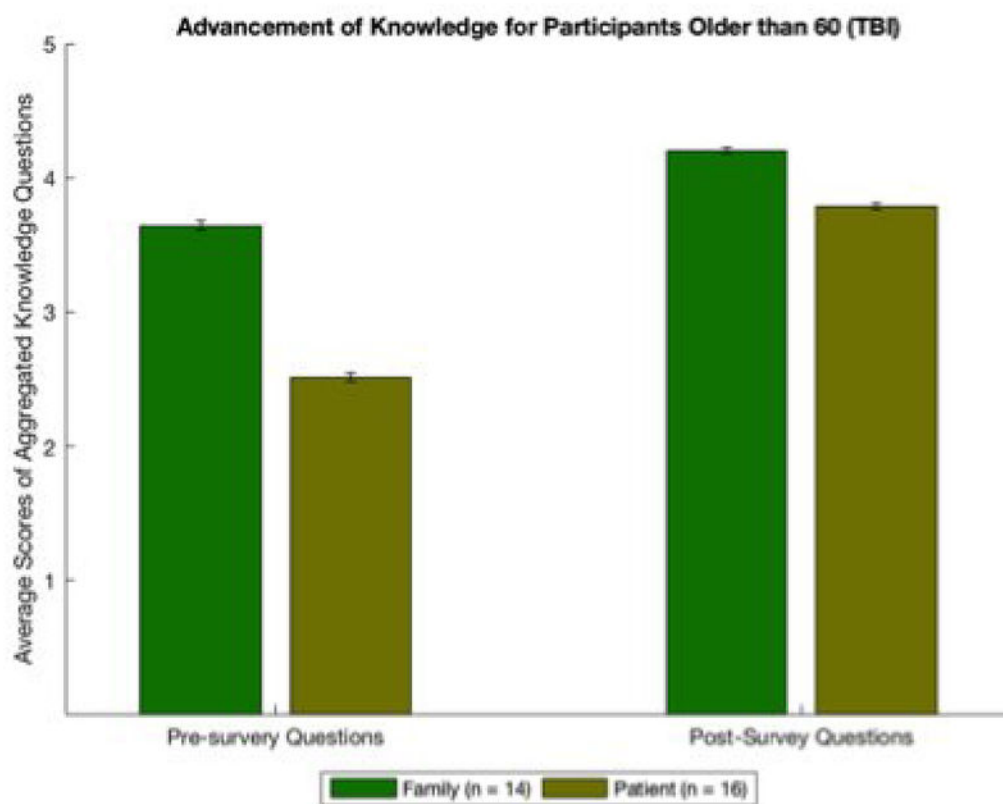


Figure 3.

Graphs demonstrating self-reported knowledge changes before and after (A) interactive eBook and (B) static paper pamphlet administration. Significant post-survey improvements are observed within both age groups after viewing (A) the eBooks or (B) reading the pamphlets, however older participants only scored significantly lower on the post-survey after viewing (A) the eBook and not (B) the pamphlet. (C) Further investigation demonstrates younger participants increased in post-survey self-reported knowledge score significantly more after viewing the eBook as opposed to the pamphlet. (D) Older participants benefited equally from the eBook or the pamphlet.





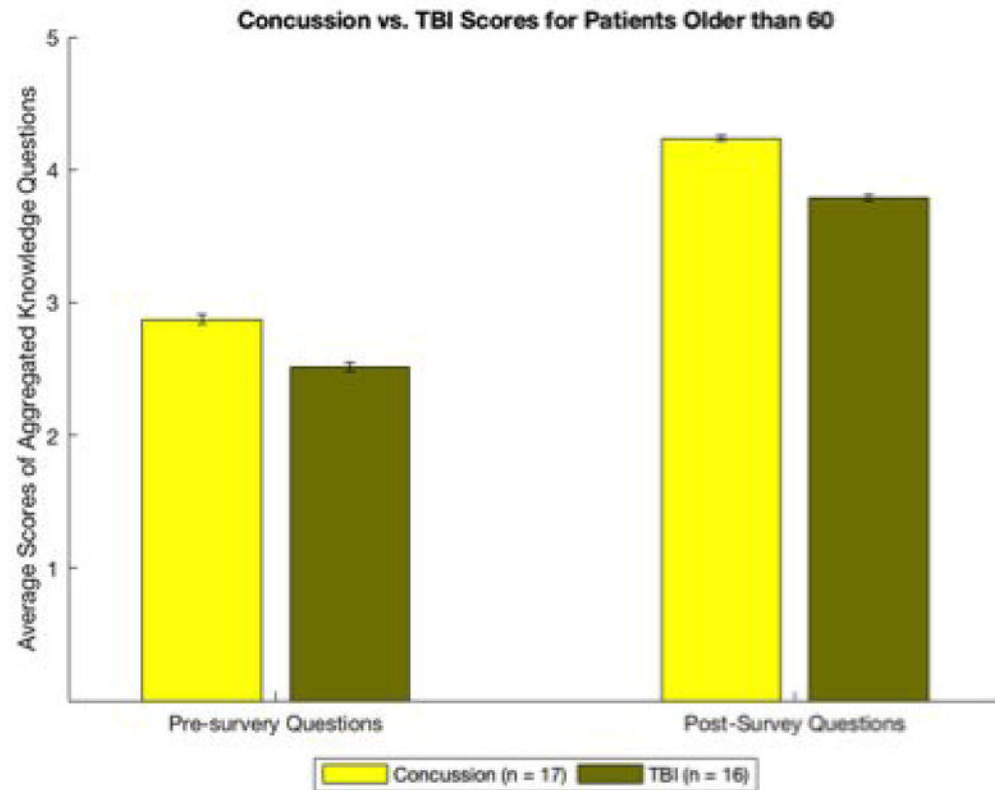


Figure 4.

Graphs demonstrating self-reported knowledge changes in older family members and patients for (A) concussion eBook and pamphlet (no significant difference) (B) TBI eBook and pamphlet (patients scored significantly lower on both pre- and post-surveys). (C) Older TBI patients scored significantly lower than same age concussion patients on the post-survey score, despite similar pre-survey scores

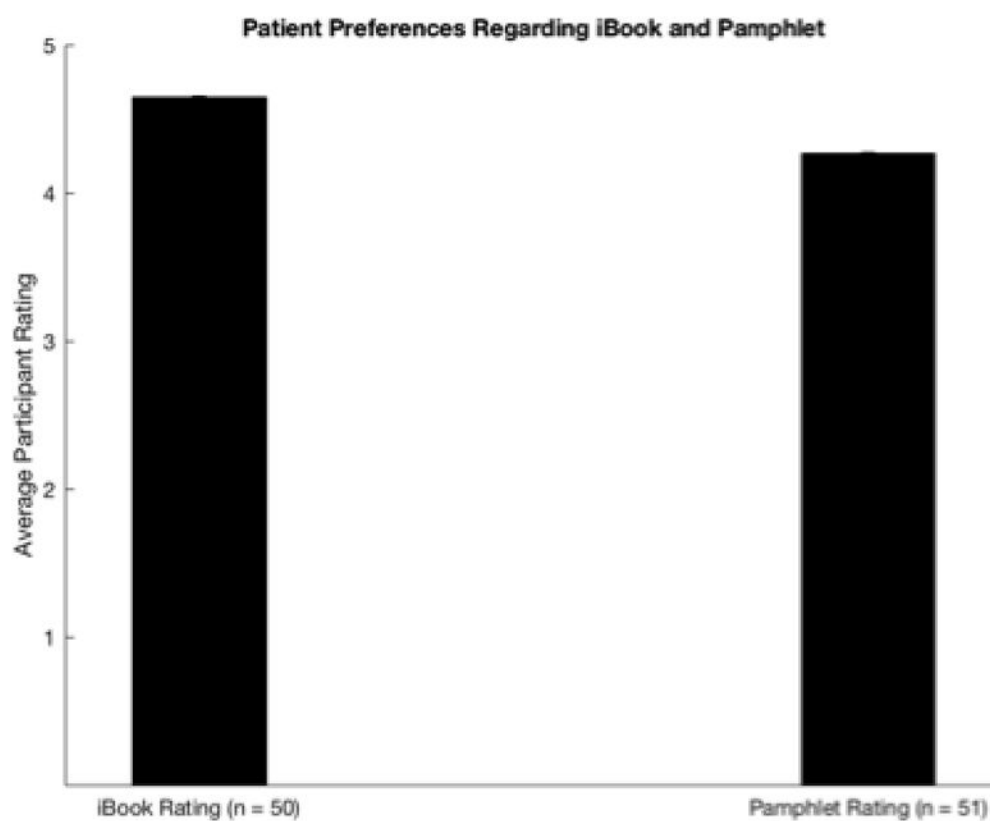


Figure 5.
Patients significantly preferred eBooks to pamphlets ($P = 1.35e-8$).

Table 1

Similar trend in pre- and post-survey scores in both pathologies.

		Concussion eBook	Concussion Pamphlet	TBI eBook	TBI Pamphlet
Age ≥ 60	Avg. Pre Survey Score	3.38	2.08 *	2.87	3.38 *
	Avg. Post Survey Score	4.25 *	4.28	3.96 *	4.02
	Difference (post – pre)	0.87	2.20	1.09	0.64
Age < 60	Avg. Pre Survey Score	3.11	3.11 *	2.57	2.52 *
	Avg. Post Survey Score	4.50 *	4.26	4.31 *	3.72
	Difference (post – pre)	1.39	1.15	1.62	1.04
N	Age > 60	19	10	20	10
	Age < 60	50	19	40	12

* Marks a statistically significant difference ($P < 0.05$) between the two age groups found within the same eBook or Pamphlet.