

Implementation of an Interactive Tablet-based Educational Intervention in the Neurotrauma Clinic: A 1-year Retrospective Analysis

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Abstract

Background: Traumatic Brain Injury (TBI) is a devastating and widely prevalent cause of death and disability in the United States. Educational interventions integrated into neurosurgical neurotrauma clinics can facilitate patient education and optimize the clinical encounter. Interactive educational modalities may enhance knowledge acquisition and patient satisfaction, however, no description of implementing such a program has been presented in the literature. The implementation of an interactive iBook-based educational intervention in an outpatient neurotrauma clinic is discussed.

Methods: Concussion and TBI iBooks and surveys were created. Then, a retrospective chart review and data analysis of 202 consecutive patients and family members presenting to the neurotrauma clinic was conducted. The participants completed a presurvey, reviewed an interactive iBook, and then completed a post-survey to test interim knowledge improvement.

Results: We discuss the process and problems encountered when creating the iBooks and implementing them in a clinical setting. Between August 1, 2015 and August 1, 2016, 93 patients (46%) and 109 (54%) family members participated in the study, for a total of 202 participants. 104 subjects reviewed a concussion iBook, and 98 subjects reviewed a TBI iBook, depending on their medical condition. Significant improvements in self-reported knowledge measures were demonstrated. Participants ranged in age from 10 to 90 years, with a mean of 45 years. The male to female ratio was 1.104:1.

Conclusions: Interactive iBooks were readily implemented into a neurotrauma clinic. Improvements in self-reported knowledge measures and strong preference for the interactive iBook were attributed to the efficacy of the educational intervention. Examples of how interactive iBooks may be a useful adjunct in the education of head injury patients and their families in the neurotrauma setting are presented.

Keywords: Concussion, Traumatic brain injury, iBook, Education, Neurosurgery

Introduction

Traumatic brain injury (TBI) is a devastating and widely prevalent cause of death and disability in the United States. It is defined as a physical injury to brain tissue that temporarily or permanently impairs brain function, and affects an estimated 1.5 million Americans every year, leading to nearly a quarter of a million hospitalizations [1]. It is disproportionately more common among teenagers and young adults [2]. Common causes of TBI include motor vehicle and other transportation-related accidents, falls, assaults, and sports activities [3]. TBI accounts for a significant financial burden due to hospitalization costs, which average \$8,189 for moderate, \$16,603 for serious, and \$33,537 for critical TBI [4]. In even mild TBI, or concussion, patients may suffer from reduced attention and executive function prior to recovery, and are additive following repeat concussion [5,6]. Due to the ubiquitous, austere, and costly nature of head injury, steps must be taken to educate patients about the condition and encourage disease-modifying and preventative measures to avoid further head injury [7].

Neurosurgeons oftentimes are tasked with educating patients and their family members about head injury, treatment options, postoperative complications, and follow-up expectations. Educational interventions may facilitate this goal, and optimize the clinical encounter. Educational interventions may promote preventative measures (e.g. helmet use in motorcyclists and bicyclists, or notifying coaches of concussion symptoms) that will either decrease the likelihood of a secondary brain injury, or prevent the exacerbation of an existing injury [8,9]. Interactive educational modalities that engage the learner may enhance knowledge acquisition and patient satisfaction [10]. The iBook, presented on an iPad, is an effective interactive educational modality that can be used with patients in a clinical setting [11]. However, the implementation of an interactive educational intervention program has not previously been described. We describe a one-year, single-institutional experience implementing interactive iPad-based iBooks in a tertiary care academic medical center. The challenges in establishing an iBook

program in the neurotrauma clinic are discussed as well as the potential benefits.

Materials and Methods

Nature of study

This retrospective chart review and data analysis study seeks to study the implementation of an iBook in a neurotrauma clinic and analyze the response to the iBook. The study took place from August 1, 2015 to August 1, 2016, and was conducted with IRB approval.

Infrastructure

A Macbook (Apple Inc., Cupertino, CA) was necessary to use the iBook's author software to create the TBI and concussion iBooks. The iBook's author software allows one to readily format, design, and create each slide (Figure 1). The iBook was preloaded onto a standard 32 gb Apple® iPad (Apple Inc., Cupertino, CA), which was used in the clinic. The clinic was the senior author's neurotrauma clinic at UC Irvine Medical Center, an American College of Surgeons verified Level I Trauma Center.

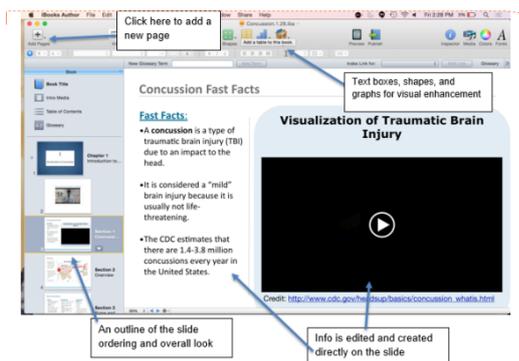


Figure 1: Creating the TBI iBook using the iBook author's software

Development of the iBooks

The iBooks were developed previously by affiliates of the University of California School of Medicine. Two separate iBooks were developed that were used in the study, whose topics include TBI and concussion [12,13]. The iBooks consist of 8-12 slides of information, presenting the etiology, symptoms, diagnosis, treatment, and follow-up care with regards to head injury. The information was written at a 10th grade level based on the Coleman-Liau Index, and each iBook takes approximately 10 minutes to read [14]. Interactive features were added, including text boxes, videos, pop-up images, and more, which allows the viewers to engage with the material (Figure 2). All information in the iBook was either cited from other sources, with references listed on the final slides, or contained original content. Original content that was created by the research team includes an introductory video clip, a video describing various

surgical interventions, and digital artwork explaining numerous neurosurgical pathologies.

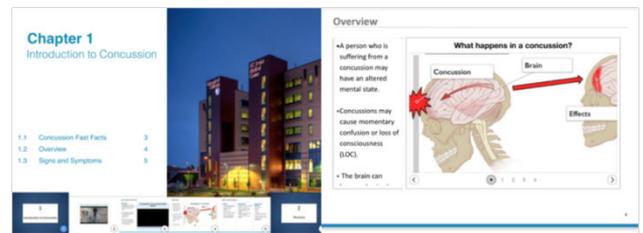


Figure 2: Screenshots of the Concussion iBook depicting integration of video content, pop-up and scrolling widgets, as well as interactive image galleries.

Development of the surveys

Pre-surveys and post-surveys were developed for this study in order to investigate knowledge changes following iBook administration. The survey responses to all questions were selected from a 5-point Likert scale, with a higher score indicating higher self-reported knowledge. The pre-survey contained fifteen questions intended to evaluate baseline knowledge of the disease, treatment options, and follow-up care. The surveys tested 3 different cognitive constructs (5 questions each): understanding, confidence levels, and comfort in treatments. In order to internally validate the survey, Chronbach's alpha was calculated. The post-survey consists of the same fifteen questions, followed by an additional set of five validation questions regarding the participant's thoughts on the iBook. Demographic questions were included at the end of the post-survey. Finally, a short thank you note was included at the end of the survey.

Translation of the iBooks and surveys

In order to provide tailored educational interventions to patients regardless of their native language, both the iBooks and surveys were translated into three languages: Spanish, Vietnamese, and Korean. Native speaking translators that were part of the research team translated the iBooks and surveys, and re-created all videos in their respective languages. A second volunteer translator then looked over the translated material to confirm its readability. These translated iBooks were used with patients or family members whose primary language was Spanish, Vietnamese, or Korean.

Implementation in the Neurotrauma Clinic

The following procedure was used to implement the iBooks in the neurotrauma clinic. Patients presenting to the clinic having had a TBI or concussion, as well as their family member and friends, were asked to participate in the study. This was done after the patients arrived at the examination room, and the physician introduced them to the research assistants. Upon consent, the subjects were given the pre-survey. After completing the pre-survey, the participants were given the iBook corresponding to their clinical diagnosis.

Participants were asked to review the information in the iBook. The research staff was immediately available if the participants had any difficulty navigating the iBook. Then, the subjects were given the post-survey, which was used to assess any improvements in self-reported knowledge. The patients and accompanying family then had a standard clinical encounter with the attending neurosurgeon.

Research personnel training

The research team administrating this study included one attending board certified neurosurgeon with a specialty in neurotrauma, a neurosurgical resident physician, one medical student, and two undergraduate researchers. All team members worked together on developing, refining, and translating the iBook and the questionnaires. They were also trained to administer the surveys and iBook.

Training was done by the attending physician and lead researcher, who created a process that the research personnel were to follow. The researchers entered the patient room, introduced themselves, and then explained the iBook. They then handed the participants the surveys, which had instructions to fill out the pre-survey first. Then, the researchers handed the participants the iBook, then had them fill out the post-survey afterwards. The research personnel were instructed not to further elaborate or explain any information on the iBook, but to be present in case there were any technical difficulties or questions, and to guide the participants through the process.

Inclusion criteria

Patients presenting to the clinic having had a TBI or concussion were asked to participate in the study, as well as any family members and friends who were accompanying the patient. Patients were given the TBI iBook if they had moderate or severe TBI (GCS 3-12) at the time of the hospital admission, or had a history of neurosurgical interventions such as intracranial pressure monitoring and/or craniotomy. Patients with mild TBI (GCS 13-15) at the time of admission were given the concussion iBook and questionnaire. The accompanying family members were given the same module that was given to the patient.

Data collection and analysis

The survey data was collected and all responses were entered into a database. Statistical analysis was performed using built in functions of IBM SPSS Statistics and MATLAB® R2016a. Specifically, IBM SPSS (IBM, Armonk, NY) was utilized to calculate Cronbach's reliability coefficient, alpha, and $ttest(x,y)$, $ttest2(x,y)$, or $anova1(x)$ MATLAB (Mathworks, Natick, MA) codes were used to perform paired t-test, unpaired t-tests, or one-way analysis of variance test respectively.

Results

Number of participants and data acquired

Between August 1, 2015 and August 1, 2016, 93 patients (46%) and 109 (54%) family members participated in the study,

for a total of 202 participants. 104 subjects (51.5%) reviewed a concussion iBook, while 98 (48.5%) reviewed a TBI iBook.

Patient demographics

96 females (47.5%) and 106 males (52.5%) completed the study, resulting in a male to female ratio of 1.104:1. All participants reported their age by indicating what age bracket they were in, starting from 0-9 years old and ending with 80+ years old. Patients ranged in age from 10 to 90 years, with a mean age bracket of 40-49 years old. The group that showed the greatest increase from the average pre-survey score to the average post-survey score was the 30-39 year olds, while the group that showed the least increase was the 60-69 year olds (Table 1). Participants in younger age groups tended to have a greater average increase in pre- to post-survey score, indicating this group reported higher advancement of knowledge after using the iBook (Figure 3A).

There were 129 English surveys (63.9%), 51 Spanish surveys (25.2%), 13 Vietnamese surveys (6.4%), and 9 Korean surveys (4.6%) completed. For all subgroups, the post-survey scores were significantly higher than the pre-survey scores, indicating that all subgroups displayed an increase in reported advancement of knowledge. The Spanish subgroup displayed the greatest increase between survey scores, while the Vietnamese subgroup demonstrated the lowest increase between survey scores (Figure 3B).

Table 1: Tabulation of patient demographics (e.g. age, gender, language, education level).

Type	Patients n =93	Family Members n=109
Pathology	Concussion n=104	TBI n=98
Gender	Male n=106	Female n=96
Age	<20 n=6 20-29 n=26 30-39 n=33 40-49 n=40 50-59 n=32 60-69 n=26 70-79 n=20 80+ n=15	
Language	English n=129 Spanish n=51 Vietnamese n=13 Korean n=9	
Education Level	Graduate School n=21 University/College n=61 Trade School n=15 High School n=72	
Subgroups (73 of the initial 202 patients were surveyed for the following information)		

Prior discussion of TBI/concussion with healthcare provider	Yes n=45	No n=28
Looked up information on TBI/concussion previously	Yes n=48	No n=25

Participants listed their level of education, with the categories including graduate school, university/college, trade school, high school, and grade school. All categories had similar increases in average survey scores following the iBook, with the high school category having the largest increase (Figure 3C).

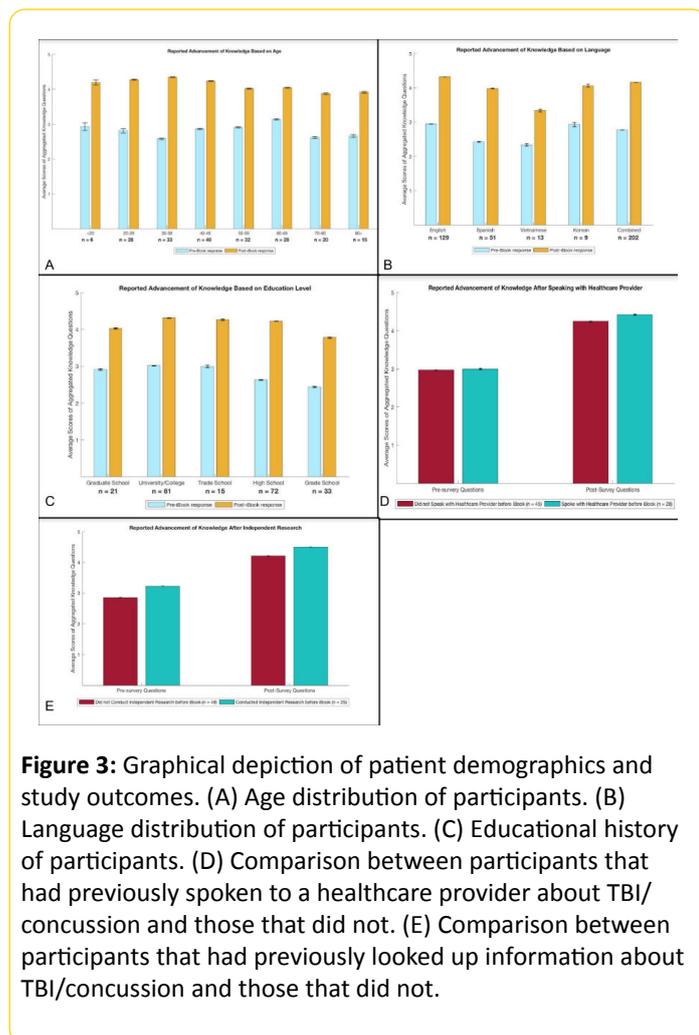


Figure 3: Graphical depiction of patient demographics and study outcomes. (A) Age distribution of participants. (B) Language distribution of participants. (C) Educational history of participants. (D) Comparison between participants that had previously spoken to a healthcare provider about TBI/concussion and those that did not. (E) Comparison between participants that had previously looked up information about TBI/concussion and those that did not.

Discussion

The iBooks were successfully implemented into the neurotrauma clinic with a favorable response. The aim of this manuscript is to describe the methodology of implementing an iBook-based educational intervention program in a NeuroTrauma clinic, and an in-depth analysis of the results of the implementation is a subject of further investigation. On average, post-survey scores were significantly greater than pre-survey scores, indicating that the iBook increased self-reported knowledge. With regards to gender, there was approximately an equal ratio of females to males. Trends among different age groups were observed, with younger groups appearing to have a

higher increase in score than older groups. Although the iBook appears to benefit people of all age groups, it may be more effective in younger patients. This may be related to their increased familiarity with mobile devices. Young patients are also vulnerable to head injury, and may be amenable to educational interventions.

A study on unreported concussion in high school football players indicates that there is a higher prevalence of concussion than previously reported in the literature [15]. This is concerning due to the catastrophic effects recurrent concussions may cause. Additionally, collegiate athletes have been shown to continue playing on the field and sustaining further head injuries even following a concussion due to lack of knowledge of the symptoms of head injury [16]. Young patients who have suffered from a head injury may therefore benefit from educational interventions that can increase awareness of the symptoms of head injury, and provide motivation to seek help or take precautionary measures to avoid further head injury.

With regards to ethnicity, the most common language iBook used was English, followed by Spanish, and then Vietnamese and Korean. This reflects the patient population in our region, as well as the greater need to provide translated and accessible information to different ethnic groups. The Spanish and English language speakers had the greatest increase in self-reported knowledge, while the Vietnamese and Korean language speakers had a smaller increase, which may be attributable to the smaller sample size or confounding translation or cultural variables.

Lastly, education level did not appear to have a significant role in affecting the survey score, with participants of all educational backgrounds demonstrating a similar improvement in survey score. This indicates that the iBook was accessible to individuals from all educational backgrounds, and was able to convey the intended information regardless of patient education.

iBook revisions

Over the course of the study, it was identified that revisions and alterations to the iBook were necessary. These revisions included condensing the iBook from its initial form to a simpler and more concise version. Several revisions were necessary to make the iBook more aesthetically pleasing and navigable for the participants. Additionally, given the wide variety of educational backgrounds of the patient in the neurotrauma clinic, it was necessary to have the information in the iBook both be accessible to all readers but also convey the intended message.

Another area of concern was translation errors. Some patients who used the iBook translated into other languages reported that the word choice could be confusing at times, due to dialectal differences within the same language. To create a fluent and easily digestible iBook in other languages, it is necessary to have multiple translators look over the iBook and make revisions as needed.

Survey revisions

The surveys were also modified at the start of the experiment in order to ensure that it was accessible to the participants, easy to read, and assessed the right information. The surveys were expanded to allow the testing of different constructs, as well as to create a measure of validity. An appropriate number of questions were used to make certain the survey was not too long, but also included enough questions to run statistical tests (i.e. five questions for each of the three constructs were used, in addition to five questions for validity calculations). Also, simple checkboxes were consistently implemented throughout the survey. To mitigate survey fatigue, the demographic questions were located at the end of the survey, as these questions are the easiest and quickest for the participant to complete.

Surveys were also slightly modified for word choice after patient response indicated some areas needed better clarification. Instructions were included at the beginning of each survey page to direct the participant to use the iBook after the pre-survey, and then continue on to the post-survey.

Difficulties of Implementation

It was noted that some patients had difficulty completing the surveys and iBook without the assistance of a trained personnel, despite the textual instructions listed on the survey paper. To promote accuracy of the survey data, all of the participants in this study were accompanied by research personnel who made sure they were following the correct procedure. In particular, older patients and patients using iBook in languages other than English had the most questions and required assistance more frequently. Older patients often had questions regarding navigating the iBook or needed assistance in filling out the surveys. Patients using the iBook in different language also had more questions on the process overall and on what the questions were asking. Research personnel who were able to communicate to these participants in the respective language were able to assist with more ease, although this was not necessary all of the time.

Costs/Time spent

The standard iPad used in this study cost \$399.99 from any online retailer; however, less costly or older generation iPads could also be used. The Macbook used to create the iBooks using the free iBooks Author software cost \$1499, however, less costly alternatives are available. Besides these two barriers to entry, no other hardware or software costs were associated with the implementation of iBooks in a neurotrauma clinic. With regards to clinical implementation costs, each patient/family interaction with the iBook took around 15 minutes, with around 10 minutes spent looking at the iBook, and 5 minutes spent completing the surveys. In the study, a research assistant was readily available to the participants in order to help administer the survey, help with technical difficulties with the iBook, and answer any questions. The necessity of having someone there to administer the iBook is a significant cost in time and labor, however, the eventual implementation of this intervention in a neurotrauma clinic could be more streamlined, with patients

receiving the iBook specific to their pathology at check in, and reviewing it during their waiting time prior to entering the exam room.

Another potential cost is the time patients spend during their clinic visit viewing the iBook and filling out the surveys, which decreases the number of rooms available to seat patients in the clinic. However, in a clinic with multiple examination rooms where patients are able to wait, this did not prove to be a major issue as there was adequate time to complete the iBook prior to the clinical encounter. Additionally, when the implementation was timed such that the iBook was reviewed when the patient was waiting for the physician, or during down time, it was found that in many cases the iBooks actually could be implemented without adding extra time to the overall visit. Therefore, with the proper integration of iBook review prior to the clinical encounter, clinical and personnel costs can be mitigated or eliminated, leaving only the \$1898.99 hardware costs for the implementation of this educational intervention.

Conclusion

The implementation of the iBook in a neurotrauma clinic proved to be successful as an educational intervention. The study found improvements in self-reported knowledge measures and strong patient preferences for the interactive iBook. The iBooks may be a useful adjunct in the education of head injury patients in the neurotrauma setting. Considering the significant number of patients and family members who did not previously research or talk to a provider about head injury, the iBook is useful in educating these patients when they present to the clinic. With the proper implementation resources, the iBooks can be used as an interactive tablet-based tool in patient education.

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