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The Development and Validation of a One Tier Diagnostic Assessment to Test Premedical Students' Misconceptions about Traumatic Brain Injury

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THE DEVELOPMENT AND VALIDATION OF A ONE TIER DIAGNOSTIC ASSESSMENT TO TEST PREMEDICAL STUDENTS' MISCONCEPTIONS ABOUT TRAUMATIC BRAIN INJURY

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Md Hasan Iqbal ENTITLED The Development and Validation of a One Tier Diagnostic Assessment to Test Premedical Students' Misconceptions about Traumatic Brain Injury WHICH WAS DEFENDED ON 4/12/2016 BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science.

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ABSTRACT

Iqbal, Md Hasan.M.S., Department of Biological Sciences, Wright State University, 2016. The Development and Validation of a One Tier Diagnostic Assessment to Test Premedical Students' Misconceptions about Traumatic Brain Injury.

Since brain injury is common in the United States, it is important for health professionals and the public to have accurate knowledge about traumatic brain injury (TBI). Understanding misconceptions is important for health educators, nurses, and physicians, who work with TBI patients. While previous studies on misconceptions about TBI have been undertaken, these have not focused on pre-medical students, nor utilized validated assessments. The purpose of this study was to develop and validate a one tier diagnostic test with a confidence index to determine premedical students' misconceptions about TBI.

Using the theoretical framework suggested by Treagust (1986, 1988, and 1995), we developed and validated the Traumatic Brain Injury Knowledge Test (TBIKT) in two phases. The pilot trial, which was an open-ended assessment, had a total of 20 items and 37 participants. This open-ended assessment, along with the literature review, helped in constructing the final multiple choice assessment. The TBIKT (Appendix A) had 43

items with an additional item about students' source of knowledge about TBI. Applying Classical Test Theory and an internal consistency definition for reliability to data from 38 participants, we found that the TBIKT can provide reliable and valid measures of students' knowledge and misconceptions about TBI.

Students showed misconceptions in identifying physical, cognitive, and emotional symptoms of TBI. This study also identified several misconceptions about TBI such as "it is likely a TBI patient may wake up from the coma without any lasting effects", "a TBI patient needs to take rest all of the time, even a little physical exercise may be harmful", and "the patient can be completely cured if enough neurons are recruited to take over the loss of the damaged ones". Validity evidence and limitations of the TBIKT are discussed and suggestions for future studies are included.

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INTRODUCTION

Traumatic brain injury (TBI) is any blow, bump or anything penetrating into the head which disrupts the regular functions of the brain (Faul et al., 2010). A TBI may be "mild" or "severe" based on the severity of the patient's mental status. Patients with a minor change in the mental status are suffering from mild TBI, patients with amnesia for a long post-injury period are likely suffering from severe TBI.

People with traumatic brain injury often suffer from difficulty reintegrating into society. One reason for this coping difficulty is the prevailing misconceptions about TBI among a wide range of people (Willer et al., 1993) which can be as damaging as the injury itself.

The recovery process of TBI is lengthy and an individual with severe brain injury may never gain complete recovery (Ernst et al., 2009). If a person with TBI reenters into the community, school or office with some deficits and is expected to perform like the pre-injury time, that may exacerbate the effects of the injury and could cause a delay in the recovery process (Guilmette & Paglia, 2002). Due to the complexity of brain injury and the complications it can cause, it is important for caregivers and other health professionals working with families and hospitals to have proper knowledge about TBI. However, misconceptions about TBI prevail even among health professionals because many do not specialize in brain injury (Swift & Wilson, 2001).

Need of the Study

In the United States, a significant number of brain injured people die or face permanent disability due to TBI. Nearly 1.7 million American people have TBI each year, 52000 (3.06%) die each year, 275,000 survivors (16.3%) need hospital care, and the remaining 1,365,000 survivors (80.7%) need at least one visit to the emergency unit of a hospital (Faul et al., 2010). TBI deserves much attention from both health professionals and the community as a whole. However, people and professionals have been carrying misconceptions about many aspects of TBI, including those related to unconsciousness, amnesia, cause of brain injury, and recovery (Gouvier et al., 1988; Guilmette & Paglia, 2004; Hux et al., 2006).

Conceptions about TBI have slightly improved over the last two decades. A nationwide poll conducted on 2000, found 1 person in every 3 was familiar with the term "brain injury" (Risher et al., 2000). If a person with TBI has misconceptions about TBI, that may lead him/her to negative consequences such as misinterpretation of the symptoms, wrong beliefs about etiology, and incorrect evaluations about treatment and the recovery process. Eventually, that person may get improper treatment, rehabilitation, and medications, which may exacerbate the condition (Hoge et al., 2009; Belanger et al., 2009; Lezak, 1978; reviewed by Block et al., 2014).

Students come to classrooms with a considerable amount of understanding based on their prior learning experiences. While all of this counts as knowledge, the conceptions are not necessarily correct. Teachers have to face the major task of addressing the prevailing misunderstandings among their students (Duit & Treagust,

1995). Therefore, teachers have to consider their student's previous conceptions about a topic before teaching starts (Driver & Easley, 1978). Evaluating the misconceptions of premedical students may enable educators and researchers to help premedical and medical students toward more accurate conceptions of TBI. Moreover, it is important to assess and address the misconceptions of premedical students before they will complete premedical education so that these misconceptions will not be carried into medical school and into their careers.

Evans and Hux (2009) conducted research on two different groups of speech-language pathology students: beginning master's students and graduating master's students. This study found a higher level of misconceptions about TBI among beginning master's students than graduating master's students. Ernst et al., (2009) conducted a study on nursing students and found a lower frequency of misconceptions about TBI than the pre-nursing students. This study also found students in an advanced level of nursing majors had more accurate knowledge about TBI than the pre-nursing students. Another study was conducted by Farmer and Johnson-Gerard (1997) on educators and rehabilitation staff, finding educators had more misconceptions than the rehabilitation specialists. But no research was conducted on premedical students who are going to join medical school to evaluate their knowledge right before joining medical school. The purpose of this study is to examine premedical students' misconceptions about TBI.

Purpose of the Study

The goal of this study was to develop and validate a one-tier diagnostic test that includes a certainty of response index to diagnose the prevailing misconceptions among

premedical students and to investigate the possible sources responsible for creating these misconceptions. The findings of this study will provide a useful document in medical education sectors. This study focused on the development of a valid and reliable Traumatic Brain Injury Knowledge Test (TBIKT) and has the following objectives:

1. To develop an instrument (TBIKT) that will identify premedical student's misconceptions about TBI.

2. To validate the TBIKT so that it can be used to assess student's misconceptions about TBI accurately.

3. To identify premedical student's misconceptions about TBI by using the reliable and validated instrument.

4. To identify the responsible sources creating misconceptions among students.

Research Questions

In accordance with the purposes of this research, I addressed the following questions:

1. To what extent is the TBIKT a valid and reliable measure for pre-medical students' understanding of TBI?

2. How does the level of misconceptions expressed in the items relate to the difficulty of the items?

3. What are the most prominent misconceptions that premedical students have about TBI?

4. Through what resources have pre-medical students acquired information about traumatic brain injury?

Definition of Key Terms

Misconceptions

Misconceptions refer to one's incorrect understandings of an idea that conflicts with scientifically-accepted understandings. Theses may obstruct a student's capacity to learn new scientific knowledge and cause harm to the society in various ways.

Certainty of Response Index (CRI)

A Likert-type scale to assess a student's degree of confidence on the answers of tier 1 of the TBIKT. The 4 options of the Likert scale were: "Guessing," "Uncertain," "Confident," or "Very Confident."

Concept

A concept is a "perceived regularity in events or objects, or records of events or objects, designated by a label," (Novak, 1995, p. 229).

Classical test theory:

According to Classical Test Theory (CTT) each assessment score (X) has a True component (T) and an Error component (E).

$$X = T + E$$

Item Difficulty

Item difficulty is used to measure the proportion of participants who answered a test item correctly. This study used the statistical index called “p-value” to calculate item difficulty. An easier item of an assessment has a higher p-value and a difficult item has a lower p-value. Unlike the p-value of parametric statistics, the p-value of CTT represents the proportion of students who answered the item correctly.

Item Discrimination

Item discrimination assesses the item’s tendency to discriminate between students of high and low ability. Point-biserial correlation is a statistical index used to determine the item discrimination for the TBIKT. The overall target point-biserial value for this study was 0.20.

Factor analysis

This type of analysis is used to test how the responses can be influenced by one or more underlying constructs.

Reliability

Reliability is the consistency of measurement of a test instrument under the same setting with the same participants. The statistical index “Cronbach’s alpha” was used to test the reliability of the TBIKT.

One-Tier Test with a Certainty of Response Index

The TBIKT includes a content response in the first tier that is followed by a confidence index for each item.

Validity

Validity of an assessment refers to whether the test can measure what it designed to measure.

Construct Validity

Construct validity is the level to which an instrument measures the target construct accurately and precisely (Hayes, Richard, & Kubany, 1995).

Content Validity

Content validity is the level of an instrument to which items of that particular instrument are relevant to the targeted construct to fulfill the purpose of the instrument (Haynes, Richard, & Kubany, 1995).

Point-biserial Correlation

This is a statistical procedure to test the validity of the items of an assessment which correlates students' right/wrong score on a single item with the total scores they receive after summing up the remaining items of an assessment (Varma, 2006).

P-Value

This is a statistic to test the validity of the items of an assessment. It is useful to determine the proportion of students who find an item correct. It is a measure of item difficulty.

Traumatic Brain Injury Knowledge Test (TBIKT)

A one tier multiple-choice diagnostic instrument with a Certainty of Response Index specifically designed to identify premedical student's misconceptions about TBI.

Assumptions of the Study

This study has the following assumptions:

1. According to CCT, the raw score of a test is made up of a true score plus random error. Scores will be fluctuating from high to low. However, the average of raw scores will be the best estimate of the true score.

2. The random errors will be normally distributed around the true score. That means, sometimes the scores will be higher because of fantastic effort and high knowledge and sometimes scores could be lower due to distracted effort or lack of knowledge.

3. Sampled premedical students are representative of other premedical school students, to whom results of this study can be generalized.

4. Students' scores on the TBIKT including the confidence level will be normally distributed.

5. A student with a higher score on the TBIKT will imply that he/she has better knowledge about traumatic brain injury.

6. There are some sources responsible for creating misconceptions about TBI among pre-medical students.

REVIEW OF RELATED LITERATURE

Background

Research has been conducted on different regions of the United States to measure whether the level of misconceptions has increased or decreased over time. Numerous studies were also conducted on different populations to identify misconceptions in those populations. The overall purpose of this review is to accumulate data on misconceptions that people in the Midwestern United States have about TBI, which were used for preparing the Open-Ended Questions (Appendix C).

This literature review is based on the electronic databases, "Google Scholar" and "PubMed" to collect research articles on misconceptions about TBI. The terms used for searching articles were: "misconceptions", ''head injury'', ''brain injury'', ''trauma'', and ''United States''. The articles were selected on the basis of some of the following criteria: being peer reviewed, publishing year is 1988 to current, association of the article with TBI, brain injury survivors as the subject population of the research, involvement of friends and family members of a survivor with the survey, and also the involvement of the health professionals with the survey. Reference sections of some papers also helped to select related articles and arrange them coherently. The exclusion criteria of articles for this review were the age of the paper (older than 1988), a study conducted outside of USA, and study conducted only on brain injury but did not address misconceptions. The reason for choosing papers published after 1988 was that Gouvier et al.'s paper that was

published in 1988 which is a pioneering research in brain injury and several replication studies of it were conducted on misconceptions of TBI at later dates.

Figure 1 illustrates how the structure of the literature review on people's misconceptions about TBI was built up for this study. Here I considered nine primary papers which were on different groups of people.

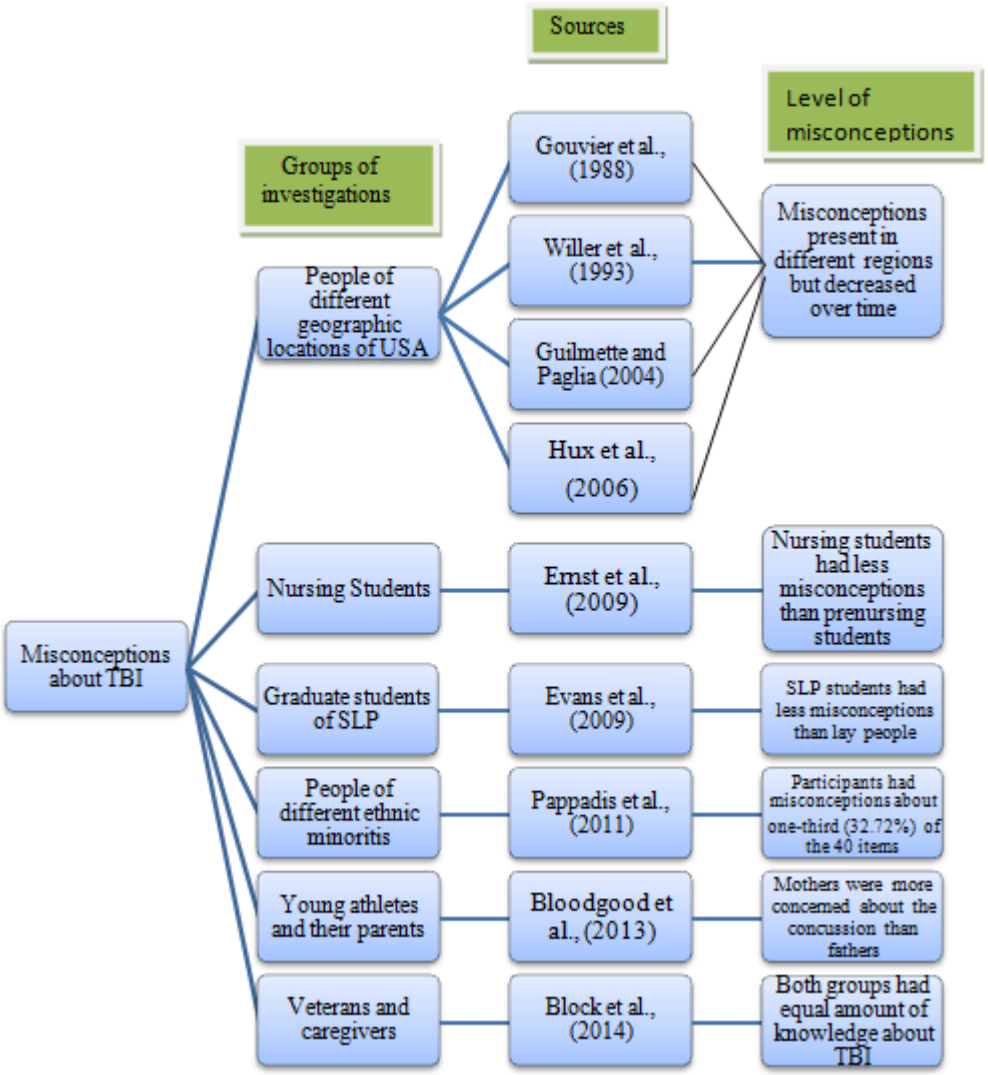

Figure 1. Graphic overview of research papers used in this review.

Misconceptions about TBI in Different Parts of the United States

Gouvier et al., (1988) conducted a survey on 221 participants at a shopping mall in southern Louisiana addressing people's common misconceptions about brain injury. The participants were from different age groups, genders, ethnic groups, with different educational qualifications, and from different economic conditions. They were divided into 4 groups on the basis of their age. The participants were further divided into 3 different ethnic groups: Black, Caucasian and a few were from other races. There were 25 items in the questionnaire from 5 different domains: seat belts, brain damage, unconsciousness, amnesia, and recovery. Moreover, the participants were asked about the source of information they had about TBI.

Participants of Gouvier et al.'s study answered most accurately for the items of the domain "seat belts". Only 16.6% had inaccurate conceptions on the statements of this domain. 11.31% inaccurately believed that "one does not need to embrace seatbelts as long as he/ she can do that before accident". In addition, 20.81% inaccurately believed that "seat belts are more necessary when they are used on long trips rather than traveling in town". Authors found 25.2% inaccurate responses for another domain "brain damage". Forty-five percent of the respondents did not agree to the statement "whiplash injuries can cause significant injury to the brain". Twenty-seven percent believed that "only a severe injury can cause brain damage". This study found overall 44.53% misconceptions on the items of domain "unconsciousness". The participants were most inaccurate (59.28%) for the idea that an individual with brain injury can wake up from the unconscious condition without any lasting effects. "Amnesia" was another domain in which 55.43% participants responded inaccurately. The authors found 82.35% of

participants had inaccurate ideas for the statement "a TBI survivor may find it difficult to recognize him/herself but can do all other activities normally". The last domain was "recovery" and 49.65% misconceptions were found in the responses of the participants. The most misconceptions (73.76%) were found in the statement "people with one head injury are prone to have another". In addition, 70% of participants incorrectly believed that "recovery from TBI is dependent on the effort of TBI affected people".

Participants of Gouvier et al.'s (1988) study mentioned the names of different sources from which they had gathered their knowledge about TBI. Forty-two percent said the sources of their information were television programs. The other sources were health professionals, friends, and print media. In addition, the authors did not find any significant difference in the level of knowledge about TBI between the two groups of participants who had experienced brain injury and who did not have that experience.

In 1993, Willer and his associates conducted a replication study of Gouvier et al., (1988). Investigators did this replication survey in two different places: Western New York (WNY) and Southern Ontario (ONT). A total of 245 adults from WNY and 68 from ONT were recruited in this study. This survey included 63% female participants from WNY and 46% from ONT.

Willer et al., (1993) compared the findings from WNY and ONT with the original results of Southern Louisiana (SLA) and found that people's overall knowledge about brain injury had increased over time. For example, 41.2% participants of SLA study had the misconception that people can wake up from a coma without any problem speaking and recognizing others. However, the percentages of this inaccurate belief

prevailed by the participants of WNU and ONT were 18% and 16.2% respectively. Participants from all three studies had a significant level of misconceptions for another item: "people with brain injury do not have any problem except recognizing him/herself or others" and the percentages of misconceptions were 89%, 82.4%, and 82.4% for WNY, ONT, and SLA studies respectively. This study suggested that misconceptions regarding brain injury were not confined to a specific geographical region, but rather had been prevailing in different areas of North America.

In 2004, Guilmette and Paglia conducted a follow-up survey of Gouvier et al., (1988) and Willer et al., (1993) in Rhode Island. The purpose of this study was to compare the findings with the results of the prior two surveys and to determine whether there was any difference in people's misconceptions. Another purpose was to analyze whether the differences were with respect to the geographical areas.

The survey of Guilmette and Paglia (2004) was conducted on 179 individuals; all of them were diverse in age, gender, and ethnicity. The sample included Caucasian, Hispanic, African-American, and others. Participants answered 19 different questions. Eleven of these were adapted from Gouvier et al., (1988). The remaining eight were forensic-oriented and developed for this study. For the first nine questions of eleven on brain injury, the authors did not find any significant difference in perceptions of their samples with the other samples of 3 different regions. For the last two of eleven questions, the authors found less misconceptions in their samples compared to Gouvier et al.'s (1988) samples. For example, 35.7% participants from this study failed to detect this statement as true: "brain damage may occur to an individual when his/her neck is injured by whiplash even without a blow to the head", whereas Gouvier et al.'s (1988) study

found 45.3% gave an inaccurate response for this item. Another segment consisted of 8 question items on head-injury litigation. The authors found a significant percentage of misconceptions among the participants for this segment. For example, two-thirds of the participants had the wrong perception about X-Ray imaging as the only way to detect brain injury. From further analysis of the questions, the authors found that age, gender, and education did not have any influence on an individual's misconceptions about brain injury. Participants who had exposure to TBI or had friends or family members, who had the experience with TBI, were more correct in answering the questions. The findings of this study suggested that people's misconceptions about TBI had not changed significantly over 8-13 years.

In 2006, Hux et al. conducted another replication survey of Gouvier et al., (1988) and Willer et al., (1993) to measure the current condition of the public's misconceptions about TBI. The survey was conducted in a shopping mall and the number of total participants was 318. Participants were 80% correct in conceptions about general information of brain injury and recovery. The authors compared their results with Gouvier et al.'s (1988) results to calculate the improvement of people's conceptions about TBI and found the range from 9.44% to 44.54%. For the item "TBI survivors behave normally except they forget about their own identity and can't recognize others", only 6.60% of the participants answered correctly. Misconceptions about two other items also increased compared to the two prior studies. One was- "people in a coma are concerned about their surroundings"; 40.25% of the participants answered correctly for this item. The misconception rate for this item increased 27% over Guvier et al.'s (1988) survey. For another item which was "a TBI survivor can never be completely cured even

he/she wants", the misconception rate was increased 56.67% over Willer et al.'s (1993) survey.

Table1

Misconceptions on different domains in different geographic locations (adapted from: Gouvier et al., 1988; Willer et al., 1993; Guilmette & Paglia, 2004, and Hux et al., 2006).

Domain	Item	Percentage (%)	Source
Brain damage	Whiplash injuries are not severe because they cannot damage to the brain significantly.	45	Gouvier et al., (1988)
		35.7	Guilmette and Paglia, (2004)
		9.75	Hux et al., (2006)
	Only a severe injury can cause brain damage.	27	Gouvier et al., (1988)
		8.3	Guilmette and Paglia, (2004)
		1.26	Hux et al., (2006)
Unconsciousness	Individual can wake up from the unconscious condition without having problem in recognizing and speaking to others.	41.2	Gouvier et al., (1988)
		18 at WNY, 16.2 at ONT	Willer et al., (1993)
		40.3	Guilmette and Paglia, (2004)
		23.58	Hux et al., (2006)
Amnesia	A TBI survivor may find it difficult to recognize him/herself but can do all other activities normally.	82.35	Gouvier et al., (1988)
		89 at WNY, 82.4 at ONT	Willer et al., (1993)
		75	Guilmette and Paglia, (2004)
		93.4	Hux et al., (2006)
Recovery	People with one head injury are not prone to have another.	73.76	Gouvier et al., (1988)
		81.2 at WNY, 88.2 at ONT	Willer et al., (1993)

		68.1	Guilmette and Paglia, (2004)
		67.2	Hux et al., (2006)
	Recovery from TBI is dependent on the effort of TBI affected people.	70	Gouvier et al., (1988)
		53.1 at WNY, 58.8 at ONT	Willer et al., (1993)
		61.9	Guilmette and Paglia, (2004)
		72.01	Hux et al., (2006)

WNY= Western New York

ONT= Southern Ontario

Nursing Students' Knowledge about TBI

Nurses are often the first caregivers for patients with TBI. They have to accurately understand the condition of the patient to give them the proper care as well as the proper guidelines to the family members of the patients. Ernst et al., (2009) conducted a study to explore the misconceptions about TBI among nursing students and to compare these with pre-nursing students. Results from this study were also compared with percentages of misconceptions that prevailed among students at another college in a study conducted by O'Jile et al., (1997).

Participants of this study were from a university in the United States mid-Atlantic region. A total of 108 students from a nursing school participated in this study. Among them, 65 were pre-nursing students and 43 were nursing majors. The highest percentage of misconceptions was found for the statements of amnesia (average 55.6%). 92.6% of the nursing and pre-nursing students incorrectly identified the statement "TBI survivors behave normally except they forget about their own identity and can't

recognize others". The lowest percentage of misconceptions was found for brain damage (average 6.6%). Only 1.29% of participants had inaccurate responses to the statement "people do not use the whole brain, so damage to a little part of the brain is not an issue". The pre-nursing students had a higher level of misconceptions than the nursing students. In addition, the students of the current study had a lower level of misconceptions than the undergraduate students of another prior study conducted by O'Jile et al., (1997).

Since this is the first documented study on nursing students' misconceptions on TBI and nurses are one group of the responsible professionals for the treatment of TBI patients, this is an important study which can give a better understanding of the level of misconceptions among nurses. A limitation of this study was the single clinical setting; misconceptions could be much lower among the nursing students specializing in brain injury and rehabilitation.

Table2.

Misconceptions of nursing and pre-nursing students on different domains (adapted from Ernst et al., 2009).

Domain	Item	Misconception in nursing student (%)	Misconception in pre-nursing students (%)
Unconsciousness	People in coma are concerned about their surroundings.	69.0	33.3
	Individual can wake up from the unconscious condition of several weeks without having problem in recognizing and speaking to others.	7.1	15.2
	Individual wake up from the unconscious condition without any lasting effects.	14.3	34.8
Amnesia	A TBI survivor may find it difficult to recognize him/herself but can do all other activities normally.	88.1	95.5

	A second blow may help to bring back person's forgotten memory.	16.7	9.1
	People may find it difficult to remember the memories after a brain injury than before.	54.5	71.4
Brain damage	An individual with brain damage may have problems in speaking, walking or with coordination.	14.3	3.0
	Whiplash injuries are not severe because they cannot damage to the brain significantly.	2.4	12.1
	Only a severe injury can cause brain damage.	4.8	0.0
	Most people are concerned about how their attitude could be influenced by brain damage.	28.6	9.1
	People do not use the whole brain, so damage to a little part of the brain is not an issue.	0.0	3.0
	An individual with brain injury does not have any emotional problems.	0.0	6.1
	People with brain damage mostly lose their mental wellbeing.	0.0	9.1
Recovery	Recovery from TBI is dependent on the effort of TBI affected people.	23.8	48.5
	People with one head injury are prone to have another.	66.7	74.2
	One head injury may help an individual to withstand the second one to the head.	26.2	28.8
	If a survivor feels good after treatment that means he/she is completely cured.	0.0	1.5
	It is necessary to be inactive and take rest while recovering.	38.1	43.9
	Individual with severe brain injury can never be completely cured even though he/she tries hard.	69.0	65.2

Table3.

Misconceptions of nursing and pre-nursing students on independently developed items (adapted from Ernst et al., 2009).

Item	Misconception in nursing student (%)	Misconception in pre-nursing students (%)
If a child can start going to school after a few months of brain injury, he/she does not have any problem with brain in future.	7.1	12.1
Damage to the brain can change a child's personality.	2.4	13.6
Children are more capable of recovering from a brain damage comparing to the adults.	97.6	89.4
Recovery is dependent on an individual's status before the brain injury.	28.6	39.4
A blow to the head can not change the behavior of an individual.	2.4	9.7

Misconceptions in Graduate Students of Speech-language Pathology (SLP)

Evans et al., (2009) conducted a study to detect how effective a speech-language pathology (SLP) course was in decreasing misconceptions about TBI among graduate students. The participants of this study were divided into 3 groups. Members of group 1(318 lay people) were the participants in a prior study of Hux et al., (2006) and the findings from that group were used for the purpose of comparison. There were 197 new SLP master's students in group 2. Group 3 had 117 participants who were graduated master's students in SLP. All the members of group 2 and 3 either had taken a course related to brain injury or had known someone who had a brain injury. The questionnaire had 18 items, 17 of which were adapted from Hux et al., (2006). These 17 items were

developed to test the knowledge about brain injury, memory problems, unconsciousness, and recovery.

The findings of Evans et al.'s study had revealed that lay people had more misconceptions about TBI than the other two groups and the newly admitted graduate students had less knowledge about TBI than the graduated students. The authors found the greatest number of inaccurate responses for the item: "people with brain injury do not have any major problem except recognizing him/herself or others". Percentages of incorrect responses for this item were 93%, 87%, and 66% for the lay people, new master's students, and graduated students respectively. The authors found 80% correct responses from all three groups on four statements of general knowledge and on one other statement about the recovery process. For the item "people in a coma are concerned about their surroundings" the authors had found 60%, 45%, and 49% misconceptions for the lay public, new master's, and graduated students respectively. More than 70% of the questionnaires were completed by the beginning students whereas only 37% of the questionnaires were completed by graduated students. This selection bias might act as a significant reason for the discrepancy in the results between these two groups.

Table4.

Misconceptions of SLP students about traumatic brain injury (adapted from Evans et al., 2009).

Item	Lay public	Beginning MS students	MS Graduate students
Only a severe injury can cause brain damage.	1	1	0
Whiplash injuries are not severe because they cannot cause significant damage to the brain.	10	15	7
An individual with brain injury does not have any emotional problems.	16	7	2
People with brain damage mostly lose	6	9	1

their mental wellbeing.			
Individuals wake up from an unconscious condition without any lasting effects.	48	55	31
Individuals can wake up from the unconscious condition lasting several weeks without having problem in recognizing and speaking to others.	24	20	7
People in a coma are concerned about their surroundings.	60	45	49
A TBI survivor may find it difficult to recognize him/herself but can do all other activities normally.	93	87	66
A second blow may help to bring back a person's forgotten memory.	29	11	9
People may find it difficult to remember the memories after a brain injury than before.	48	56	29
Recovery from TBI is dependent on the effort of TBI affected people.	53	24	17
People with one head injury are not prone to have another.	68	69	31
One head injury may help an individual to withstand the second injury to the head.	30	33	17
If a survivor feels good after treatment that means he/she is completely cured.	3	1	1
It is necessary to be inactive and take rest while recovering.	40	23	24
Individuals with severe brain injury can never be completely cured even though he/she tries hard.	72	57	44

Misconceptions among Different Ethnic Groups

Pappadis et al., (2011) conducted an investigation on 58 individuals, all of whom had TBI, were at least 18 years old, and did not show any evidence of a prior neurological disorder. The setting for this survey was a trauma center in Houston, TX. Participants were 52% Hispanic, 48% Black, and English was the primary language for 76% of participants. There was also a significant difference in educational qualifications

among the participants, and the majority of them were not economically privileged. The questionnaire consisted of 40 items within 7 different areas of common misconceptions about TBI (CM-TBI). The investigators adapted 24 items from Gouvier et al., (1988) and the remaining 16 items were specifically developed for this study.

The investigation of Pappadis et al., (2011) found the percentage of misconceptions among the ethnic minorities was 32.72% by using the dichotomized scoring scheme which considered a "probably true" answer as true and a "probably false" as false. The authors had also calculated the percentage of misconceptions by considering an uncertainly answered correct answer as wrong and found 45.47% of participants had misconceptions about TBI. The investigators found 37.30% incorrect responses from the participants who had not completed high school and 28.06% in those who had at least completed high school. In addition, they found 29.77% of English-speaking participants had misconceptions regarding TBI whereas the percentage was much higher for Spanish speakers (41.97%). They found that 64.3% of Blacks and 83.3% of Hispanics had misconceptions on "a TBI survivor may find it difficult to recognize him/herself but can do all other activities". They also found a 50% misconception rate in Blacks and 63.3% in Hispanics on another item "since brain injured people face problems in their daily life, they have a better understanding about these."

This study (Pappadis et al., 2011) was unique in its fundamental criteria of ethnicity. However, there were few limitations of this study. Participants had defined themselves as Black or Hispanic and there was no major group of ethnic participants like Caucasian involved in the investigation. In addition, this study had a small sample size;

future studies with larger and more diverse sample sizes should give a more accurate idea about TBI conceptions.

Table5.

Misconceptions in different ethnic groups about traumatic brain injury (adapted from Pappadis et al., 2011).

Domain	Item	Blacks (Percent)	Hispanics/Latinos (Percent)
Brain damage	Only a severe injury can cause brain damage.	3.6	16.7
	People do not use the whole brain, so damage to a little part of the brain is not an issue.	10.7	10.0
	People with brain damage are distinctly different from those who do not have brain injury.	10.7	36.7
	Whiplash injuries are not severe because they cannot damage the brain significantly.	25.0	23.3
Brain injury consequences	An individual with brain injury may be easily angered.	7.1	20.0
	Personality can be changed after a brain injury.	14.3	13.3
	An individual with brain damage may have problems in speaking, walking or with coordination.	0.0	10.0
	Most people are concerned about how their attitude could be influenced by brain damage.	7.1	23.3
	Since brain injured people face problems in their daily life, they have better understanding about these.	50.0	63.3
	An individual with brain injury may feel depressed and hopeless.	10.7	3.3
	Alcohol may affect a brain injured person differently.	17.9	10.0
	An individual may experience change in his/her behavior after an injury to the brain.	3.6	10.0
Unconsciousness	Individuals wake up from an unconscious condition without any	25.0	43.3

	lasting effects.		
	Individuals can wake up from an unconscious condition of several weeks without having problems in recognizing and speaking to others.	39.3	40.0
	People in a coma are concerned about their surroundings.	14.3	26.7
Amnesia	A TBI survivor may find it difficult to recognize him/herself but can do all other activities. normally.	64.3	83.3
	A second blow may help to bring back a person's forgotten memory.	14.3	26.7
	People may find it difficult to remember the memories after a brain injury than before.	32.1	26.7
	A brain injured person may find it difficult to remember prior events but is good in learning new things.	75.0	83.3
Recovery	Recovery from TBI is dependent on the effort of TBI affected people.	78.6	73.3
	People with one head injury are prone to have another.	67.9	40.0
	One head injury may help an individual withstand the second injury to the head.	32.1	40.0
	If a survivor feels good after treatment that means he/she is completely cured.	17.9	56.7
	It is necessary to be inactive and take rest while recovering.	17.9	33.3
	It usually takes 5 months to be completely cured from brain injury.	17.9	23.3
	An individual with severe brain injury can never be completely cured even though he/she tries hard.	57.1	36.7
	When a brain injured person can walk after the injury, he/she can be considered as almost fully recovered.	28.6	36.7
	Recovery is a continuous process for brain injured people which	7.1	13.3

	may go on slowly even after 1 year.		
	An individual with brain injury may have to go through lot of physical pain before getting complete recovery.	28.6	53.3
	It takes several months to be completely recovered from brain injury.	21.4	33.3
	A brain injured person can give the most accurate information about his/ her recovery.	82.1	83.3

American Young Athletes' and Their Parents' Knowledge about TBI

Bloodgood et al., (2013) conducted a survey to measure knowledge of concussion among athletes and their parents. This online survey had selected 252 young athletes and 300 parents of athletes from different ages, gender, and ethnicities. Among the participants, 84% of the young athletes and 85% of their parents reported that they were informed about concussion. Seventy percent of the young athletes agreed that concussion is a "critical issue;" 54% of them were 13-15 years old. Eighty-four percent of parents recognized concussion as a "critical issue;" 68% of them were mothers and 34% were fathers of the young athletes. Investigators also found the parents who were more frequent in using the internet strongly considered concussion as a "critical issue". Early teen (13-15 years of age) athletes and their parents were more concerned about the severity of the concussion. Therefore, this article suggested that teens of early ages and their parents were a suitable target population to increase awareness about concussion. This study also suggested that mothers were more concerned about the concussion than fathers and considered concussion as "critical issue" for their early teen child. One parallel study conducted by Coghlin et al., (2009), reviewed by Bloodgood, et al., (2013),

suggested that mothers were more capable of successfully identifying a child's signs and symptoms of concussion than the fathers.

This study was a useful source to understand the current knowledge and attitudes of young athletes and their parents about concussion. There were some limitations of this study. Participants of this study were selected on the basis of their availability. The term "critical issue" was not explained to the subjects of the investigations. So individuals had to interpret it from their personal knowledge. In addition, the online methodology that was followed by this survey was itself questionable because it involved mostly those participants who had access to the internet. Moreover, participants could obtain information from different websites about concussion while answering the questions which could skew the results of the study.

Table6.

List of question items and respective target groups for Bloodgood, et al.'s (2013) survey.

Question Item	Target group	Positive (%)	Negative (%)
Have you heard about concussions?	Youth	84	12
	Parents	85	14
Do you think concussions are a critical issue?	Youth	84	7
	Parents	70	10
Are you fearful for that your friends may find you dumb about concussions?	Youth	7	69
Do you find the topic "concussions" as important to look for information?	Parents	55	45

Knowledge of Veterans and Caregivers about TBI

An investigation was conducted by Block et al., (2014) to test the level of knowledge and misconceptions of mild TBI among veterans and their friends and family members. A total of 150 participants were included in this study, among them 100 were veterans and remaining 50 were caregivers. The questionnaire had 60 items addressing 22 different symptoms of TBI.

Block et al., (2014) expected to observe a higher level of knowledge about TBI in veterans rather than their friends and family members. However, after recording the responses from the participants they found the friends and family members of TBI patients had an equal amount of knowledge to identify mild TBI, the recovery process, and treatment of TBI. In addition, although the investigators expected more accurate answers from participants who had previous education of TBI than participants who did not have education on TBI, they found no significant difference between these two groups. One treatment item was "a patient would benefit from memory and attention testing", 16.9% of veterans and 14.6% of friends/family members answered the item incorrectly. Another recovery item was "TBI patients are more likely to experience another brain injury" which was answered incorrectly by 45.8% of veterans and 64.6% of friends/family.

Block et al., (2014) is the first study to explore veterans' knowledge about mild TBI. The authors had suggested that both of the groups of this study had a significant lack of knowledge about the symptoms of TBI which were being supplemented by different media. Further research can be conducted about the role of

these media in creating misconceptions regarding mild TBI. One of the limitations of this study was the small sample size which was from one institution. The results found from one institution do not necessarily represent overall level of veteran's knowledge about mild TBI, so future research is needed to validate the conclusions.

Table7.

Misconceptions among veterans and their friends/family members regarding different types of symptoms about TBI (adapted from Block et al., 2014).

Symptoms	Items	Percentage of misconception in veterans (%)	Percentage of misconception in friends/family members (%)
Physical symptom items	Headaches	4.0	0.0
	Dizziness	6.0	6.0
	Vision problems	8.1	4.2
	Nausea	21.5	16.6
	Hearing problems	22.1	34.1
	Change of taste and smell	24.5	36.9
	Trouble controlling bladder	46.8	41.7
	Drooling	65.2	58.4
	One side of the body becomes weak	76.6	67.4
Cognitive symptom items	People may find it difficult to remember the memories after a brain injury than before.	4.0	6.1
	Trouble concentrating	2.1	10.0
	Losing possessions	9.5	24.0
	Forgetting about own identity	77.0	68.0
	Forgetting known people	86.9	80.0
	More problem in spelling than before	85.9	87.8

Psychological symptom items	Easily annoyed	15.3	22.9
	Feeling depressed	15.3	31.2
	Feeling fatigue	23.9	38.8
	Do not experience wild mood swings	61.2	60.4
	Nightmares	74.2	58.3
	Racing thoughts	75.2	69.4

Discussion of Findings from Previous Research

According to Glynn and Duit (1995), a conception is the model of an object or understanding about an event to a learner. Conceptual change of people or learners has great influence in improving instructional behavior, but evidence shows that the improvement in the behavior is a rather complicated and lengthy process (Treagust & Duit, 2008). This review provides accumulated information of what people in the United States think about TBI and a cross-sectional analysis of how their conceptions have changed over years. Data from different surveys on people's understandings about TBI suggest that misconceptions are prevailing in different parts of United States. The replication surveys (Willer et al., 1993; Guilmette & Paglia, 2004; Hux et al., 2006) of Gouvier et al., (1988) were conducted to measure the overall change in people's understanding about TBI. This review also gathered information about how people of different ethnicities and professions like athletes, nursing students, veterans are endorsing inaccurate beliefs about TBI.

To test the misconceptions about TBI in a quantitative way, developing and validating an assessment is a prerequisite. A well-developed assessment for a target population could bring out an overall scenario of misconceptions prevalent in that population. The assessment on misconceptions developed by Gouvier et al., (1988) was

successful in getting an overall idea about TBI which was followed later by Guilmette and Paglia (2004), Hux et al., (2006) etc. Ernst et al., (2009) also adapted questions from Gouvier et al., (1988), but had an independently developed section of items for their research conducted on nursing and pre-nursing students.

Since this literature review has investigated the existing knowledge of TBI and potential reasons responsible for the misconceptions, this may be a useful document for health professionals, and researchers who will work on misconceptions in the future. Health professionals should be able to identify the level of misconceptions people had regarding brain injury and provide valuable information to friends and family members of survivors which will eventually make the situation more favorable for the survivors. Future researchers who will conduct research in misconceptions about TBI may find this review helpful to understand how misconceptions vary across different domains of TBI and in designing assessments to test misconceptions for a target population. Indeed, this is what I propose to do in this study.

Misconceptions can be changed. To make a change in people's understanding about TBI, the specific inaccurate beliefs prevailent among people should be addressed first (Strangman & Hall, 2004; Lipson, 1982). This review has considered nine primary papers to gather information about people's misunderstandings about TBI. Now it is important to make people concerned about TBI by giving emphasis on the proper knowledge of different domains like coma, brain damage, amnesia, and recovery. I utilized this review of literature in preparing Open-Ended Questions (Appendix C) which was ultimately used to construct a multiple choice assessment.

METHODOLOGY

This chapter is comprised of three sections. The first section includes the theoretical framework I used in developing and validating the assessment for measuring premedical students' knowledge about TBI. The second section briefly summarizes and points the reader toward the literature review of this study. The third section describes the statistical procedures to determine the reliability and validity of the TBIKT.

Developing and Validating the TBIKT

The framework developed by Treagust (1986 1988, and 1995) was followed in the development and validation processes of the TBIKT.

According to Treagust (1995), three main stages should be followed in order to develop a diagnostic tiered test (DTT):

1. "Defining the content
2. Obtaining information about students' conceptions
3. Developing a diagnostic instrument" (p.330).

This study followed the structural model (Figure 2) of the theoretical framework. This model exhibits the step-by-step procedures which were followed during the development and validation of the assessment.

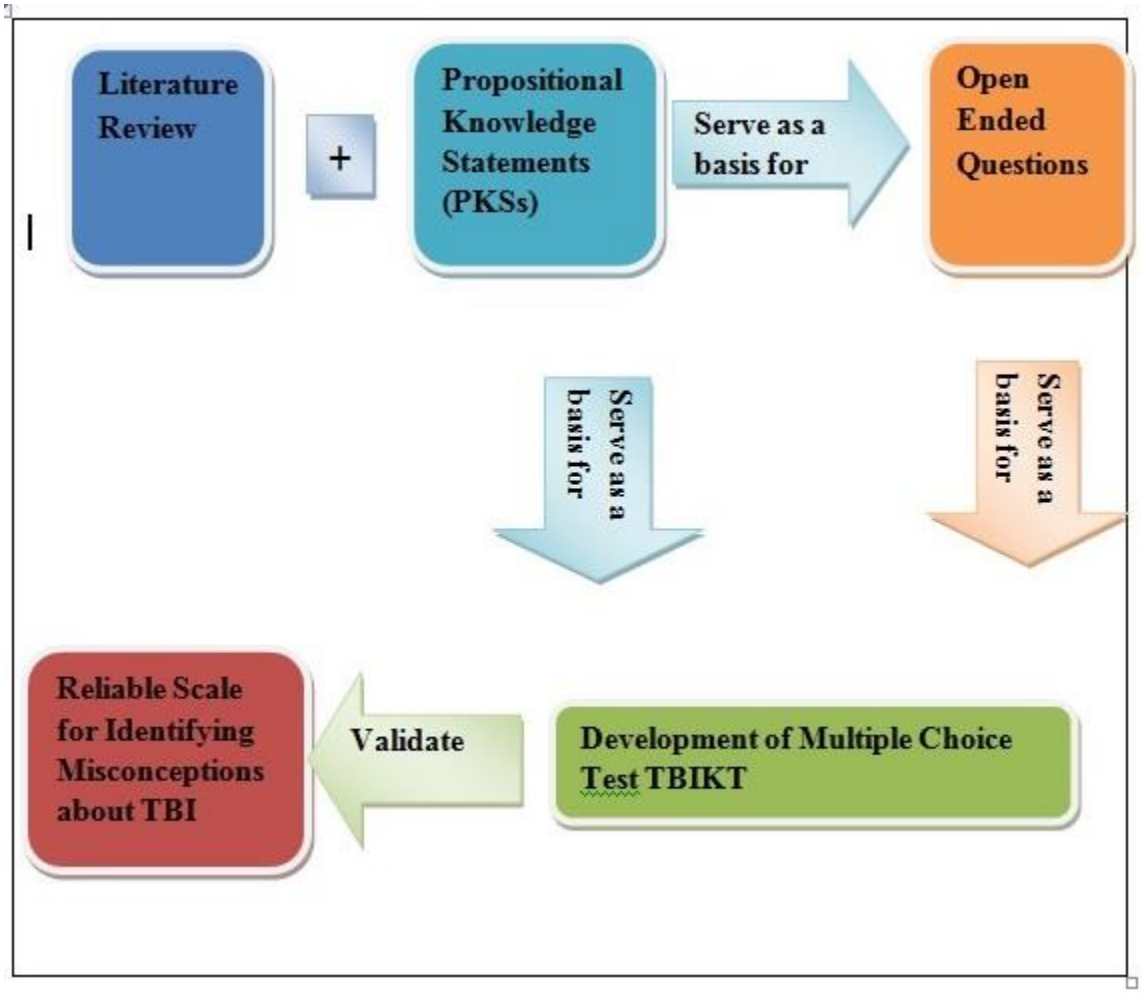

Figure 2. Structural development model for the TBI Knowledge Test (TBIKT).

Stage One: Formation of Fundamental Ideas about TBI by Defining the Content

The target of this stage was to identify the propositional knowledge statements (PKSs) to define the content of TBI which is considered to be important by the scientific and medical community. The PKSs were derived from several published articles on brain injury and from fact sheets of the "Brain Injury Association of America"

(http://www.biausa.org/glossary.htm), "The Center on Brain Injury Research & Training" (http://cbirt.org/tbi-education/about-tbi/), and Ernst et al., (2009). The developed PKSs were validated by three experts in the field of education and neurology.

Table8.

PKSs required for the conceptual understanding of the Traumatic Brain Injury (TBI).

Number	PKSs
1	Traumatic brain injury is an alteration in brain function due to an external mechanical force.
2	Typical Causes of TBI: Falls, firearms, motor vehicle accident, sports injury.
3	An acquired brain injury (ABI) is an injury to the brain that has occurred after birth.
4	Typical causes of ABI: stroke, substance abuse, near drowning, infectious disease, seizure disorders, tumor, electric shock, toxic exposure, lightning strike, oxygen deprivation.
5	Physical symptoms of TBI: problems in vision, hearing, speech, and motor coordination; headaches, dizziness, nausea, change of taste and smell, trouble controlling bladder, paralysis.
6	Cognitive symptoms of TBI: trouble concentrating, loss of items, short term memory deficits, forgetting about own identity, forgetting known people, slowness of thinking, impaired communication skills, problems in writing, spelling, planning, and judgment.
7	Emotional symptoms of TBI: Easily annoyed, rapid mood swings, self-centeredness, anxiety, depression, restlessness, fatigue, and nightmares.
8	If one suspects a head injury, first he/she needs to go to a physician for confirmation.
9	A person with a head injury needs to have lots of rest. He/she should not come back to daily activities without the permission of a physician.
10	Since people with one head injury are prone to have another, a person with a TBI should avoid doing anything that could cause another blow to the head.
11	A brain injured person should talk with a doctor when it's safe to drive a car because he/she may lose the ability to react quickly after a head injury.
12	A person with TBI should take only the medications approved by their doctor, and should not drink alcohol without the permission of the doctor.
13	Writing things down is a good practice if the brain injured person finds it difficult to remember things.

14	A person with TBI may lose some skills and need help of others to re-learn those skills.
15	A brain injured person is not concerned about what is going on in his/her surroundings when in a coma.
16	An individual with an injury to the head wakes up from the unconscious condition with a greater possibility to have lasting effects on the brain.
17	A second blow to the head does not help the person to bring back forgotten memory.
18	An individual with TBI usually finds it more difficult to remember the memories after a brain injury than before.
19	An individual with brain damage may have problems in speaking, walking or with coordination.
20	Whiplash injuries are severe because they can cause significant damage to the brain even without any direct blow to the head.
21	Most people are not concerned about how their attitude could be influenced by brain damage.
22	Damage to a little part of the brain may cause significant harm.
23	An individual with one head injury is prone to have another.
24	People with one head injury have less ability to withstand a second blow.
25	If a survivor feels good after treatment, that does not mean he/she is completely cured.
26	When a person with TBI is in the recovery process, he/she may need to exercise and does not necessarily need to have rest all time.
27	An individual with severe brain injury can never be completely cured even though he/she tries hard.
28	Since undeveloped areas of the brain mature from previously damaged portions and it is difficult to predict the later development, younger brains are comparatively more vulnerable than the matured brains.

Stage Two: Literature Review of People's Misconceptions about TBI

This review was based on the electronic databases of "Google Scholar" and "PubMed" to collect research articles on people's misconceptions about TBI. The target of the literature review was to identify the research conducted on people's misconceptions about TBI. A literature review is useful for building up one's basic information for preparing open-ended and multiple choice questions (Treagust, 1995).

Several research studies related to brain injury misconceptions, which were conducted on people of different areas, ages, gender, and professions, were reviewed thoroughly, e.g., Gouvier et al., 1988; Guilmette & Paglia, 2004; Hux et al., 2006; Evans et al., 2009. The reader should consult the *Review of Literature* section for an extensive discussion of these studies.

Stage Three: Development of the Diagnostic Instrument- TBIKT

A specification grid was designed in the third stage. This grid was useful to develop the items aligning the PKSs and previous research findings related to this study. The objective to construct the specification grid was designed to ensure that all portions of the TBIKT had content validity.

Table9.

Specification Grid of the TBIKT.

Item	PKSs, Related Literature
1	1,2
2	Faul et al., 2010
3	Faul et al., 2010
4	1,2,4
5	1, Faul et al., 2010
6	Ernst et al., 2009
7	27
8	Willer et al., 1993
9	5
10	6
11	7
12	8
13	9
14	10
15	22
16	22
17	11
18	12
19	16
20	Ernst et al., 2009
21	15
22	15
23	17
24	18

25	20
26	21
27	23
28	24
29	25
30	26
31	27
32	28
33	Ernst et al., 2009
34	Ernst et al., 2009
35	Ernst et al., 2009
36	Guilmette & Paglia, 2002
37	Pappadis et al., 2011
38	Pappadis et al., 2011
39	Data of OEQ 1, response 30
40	14

Treagust (1988,1995) recommend making several drafts before the final DTT. The final TBIKT was revised for each of the content validations from 5 specialists in the field of neuroscience and education. The TBIKT (Appendix A) was a single tier multiple choice test along with a certainty of response index (CRI). The review of literature and the PKSs worked as the basis for developing open-ended questions. The responses of the Open-Ended Questions (Appendix C) together with the PKSs and the review of literature worked as the basis for developing the multiple choice assessment. The target was to prepare a valid and reliable one-tier test which included a CRI.

Certainty of Response Index (CRI)

The CRI is useful to identify a student's level of knowledge on a subject precisely (Hasan et al., 1999). The TBIKT was comprised of a 4 point Likert scale to determine a student's degree of confidence about their tier 1 response: "Guessing," "Uncertain," "Confident," or "Very Confident." The CRI scores varied from 1 to 4 for each item of the TBIKT. The CRI matrix (Table 10) was used to calculate scores and to diagnose guessing. An important aspect of this matrix is that it indicates that reporting of confidence is a key criterion for a student's response to count as knowledge. A

misconception is defined as knowledge of an idea that is considered incorrect by the scientific and medical community.

Table10.

Certainty of Response Index (CRI). Modification of the confidence matrix used for Odom and Barrow's Three-Tier DODT, 2007; adapted from the PhD thesis of Schaffer, 2013.

	Low CRI (< 2.0)	High CRI (> 2.0)
Correct Answer	Correct answer and low CRI- Lack of Knowledge (lucky guess)	Correct answer and high CRI- Knowledge of correct concepts
Wrong Answer	Wrong answer and low CRI- Lack of Knowledge	Wrong answer and high CRI- Misconceptions

Reliability

It is important to ensure the reliability of educational assessment instruments. Popham (2002) defines reliability as the consistency of measurement of a test. Errors in the measurement, or imprecision of measures, is reflected by low reliability.

There are three different ways to maintain the consistency or ensure the reliability of an educational assessment: stability reliability, alternate form reliability, and internal consistency reliability. Stability reliability is referred to as test retest reliability which deals with consistency of a test over time. Alternate form reliability deals with consistency of results between two or more equivalent forms of the same test. Internal consistency is different than the stability and alternate form reliability which does not use students' test scores of tests to measure the reliability, it rather focuses on whether the items of an assessment are functioning consistently, treating each item like its own experimental trial. Internal consistency was used for testing the reliability of the TBIKT

because it measures the degree of homogeneity for the items on the assessment. A higher homogeneity among the items represents the higher internal consistency of the assessment, and provides one indicator of the extent to which items are measuring the same thing. The internal consistency of a test is qualified using Cronbach's alpha. Cronbach's alpha was used to test the internal consistency of the TBIKT. The ideal Cronbach's alpha value for a reliable test should be ≥ 0.70 (Crocker and Algina, 1986), which was set as a goal for the TBIKT. For multiple choice instruments α ≥ 0.50 is acceptable (Nunnally, 1978; reviewed by Schaffer, 2013).

Cronbach's alpha was calculated by the following formula:

$$\alpha = \frac{K\left(1 - \frac{\sum_{i=1}^{K} \sigma_{Yi}^2}{\sigma_X^2}\right)}{K-1}$$

Here, σ_X^2 is the variance of the observed total test scores, and $\sigma_{Y_i}^2$ the variance of item i, and K is the number of items. According to Cronbach (1951), if the items are scored as 0 and 1, a shortcut formula is:

$$\alpha = \frac{K\left(1 - \frac{\sum_{i=1}^{K} P_i Q_i}{\sigma_X^2}\right)}{K-1}$$

Where, P_i is the proportion scoring 1 on item i, and Q_i = 1 - P_i. Since the data of the TBIKT were analyzed by dichotomously, this formula was followed for calculating the Cronbach's alpha value of the TBIKT.

Validity

According to Popham (2002), a test with a valid score must be reliable; however, a test with reliable results does not necessarily ensure the validity of the results. A test could be remarkable in consistency of getting results for such a construct that the test developer actually did not intend to measure. For example, if the test developers design an assessment to test student's knowledge about TBI in a language that is difficult to understand for the students, that test will actually measure the student's knowledge about the language rather than their knowledge about TBI. In that case the test results would be consistent but not valid. A test can be considered valid when it can measure what it was intended to measure successfully.

In development and validation of the TBIKT, two types of validity were considered: content validity and construct validity. Popham (2002) defined content validity as "the adequate presence of different domains of an assessment about which inferences are to be made," (p.53).

Content Validity Analysis

The PKS's and the review of literature worked as a basis for preparing the open-ended assessment. The open-ended assessment was then checked for content validity by several experts in the field of TBI. The multiple choice TBIKT was designed by using the PKSs, literature review and the qualitative data collected from the open-ended assessment. This instrument along with the PKSs were then sent to five specialists in the field of education and neurology for content validation. The expert's review provided feedback on the extent to which items were accurate with respect to accepted

understandings of TBI. For each of the items on the TBIKT, all 5 specialists agreed that it is accurate and reflective of its intended PKS.

Construct Validity Analysis

Item analysis is an essential process to ensure that all the items have the minimum quality-control criteria (Varma, 2006). According to Classical Test Theory (CTT) each assessment score (X) has a True component (T) and an Error component (E). One formula of CTT is as follows:

$$X = T + E$$

CTT assumes that the total procedure of an assessment may have some random error which may create a band of error around the true score. Reliability is an index of the extent of this error.

This study used a single tier assessment with a confidence scale (CRI) for testing the premedical student's knowledge about TBI. Each item of the content tier was coded either as 1 or 0, with 1 for a correct answer and 0 for an incorrect answer. The student indicated agreement or disagreement along a 4-point Likert scale (guessing, uncertain, certain, very confident) for their answer of tier 1 in the CRI section.

After completion of the scoring for each question, an item analysis was performed by using statistical tests for item discrimination and item difficulty. This item analysis was necessary for quantifying the construct validity of items and revising the TBIKT accordingly.

Item-level Construct Validity

Item Discrimination

Item discrimination addresses the extent to which responses differ by student ability. Point-biserial correlations were used as indices of item discrimination. A point-biserial correlation is an effective way to catch any error during the flow of the process from developing the test material to recording the scores to ensure the validity of the test. The range for point-biserial values varies from -1.0 to +1.0. The overall target point-biserial value for this study was 0.20 or above. If the calculated point-biserial correlation is close to +1.0, we can say that students who got high scores on the overall test got the item right and the students who got low scores on the overall test got the item wrong. These two cases are indicative of a productive item. On the contrary, if the calculated point-biserial correlation is negative, that indicates that students with low scores on the overall test got the item right and students with high scores got the item wrong (Varma, 2006). This would represent anomaly in the test which could result from confusing wording or the item being off target with respect to TBI.

Item Difficulty

The preliminary item analysis was performed using item p-values to assess the difficulty level of the items. Unlike the p-value of parametric statistics, the p-value of CTT represents the proportion of students who answered the item correctly. The p-value was multiplied by 100 to get the percentage of students who were correct in answering the question. The easier items had higher p-values and a lower p-value indicated a higher level of difficulty. A valid test should have p-values between 0 to 1, concentrating around

0.5 (Varma, 2006). The goal of the TBIKT was to have items with varying difficulty from easy to hard. According to internal psychometric guidelines for classical test theory set by "Prometric" (https://www.prometric.com/en-us/news-and-resources/reference-materials/pages/Internal-Psychometric-Guidelines-for-Classical-Test-Theory.aspx), the optimal p-value for a test item should range from 0.30-0.89.

Test-level Construct Validity

Factor Analysis

The factor analysis for the TBIKT was performed by exploratory factor analysis (EFA). The purpose of using EFA is to identify clusters of constructs on an assessment which influence the set of responses (Fabrigar & Wegener, 2011).

The exploratory factor analysis was performed by the following steps:

1. Collection of measurements.

The variables were measured on same experimental units.

2. The correlation matrix was obtained between each of the variables.

3. Selection of the number of factors for inclusion:

We used the "Scree test" (Cattell, 1966) to determine the number of factors underlying the item responses on the TBIKT assessment. According to the "Scree test", the eigenvalues of the correlation matrix were plotted in descending order. A number of factors were then used which were equal to the number of eigenvalues that occured just before the last major drop in magnitude.

4. Extraction of initial set of factors:

Factors were extracted from the item response data using Stata to develop a set of component scores for each retained dimension.

5. Rotation of the factors to a final solution:

The purpose for factor rotation was to find a factor solution that was similar to the initial extraction. I used the oblique rotations to produce correlated factors rather than orthogonal rotations which produced uncorrelated factors (Jolliffe, 1986). An oblique rotation was preferred in this study because it was reasonable to expect that different subscales underlying TBI would be correlated. Oblique rotation was performed by the Promax method (Hendrickson & White, 1964).

Where Do Students Get their Information about TBI?

An additional survey was conducted to find reported information sources premedical students' have used to learn about TBI. The survey included single question with 11 options: (1) newspapers, (2) magazines, (3) TV, (4) movies/drama, (5) friends, (6) family, (7) health professionals, (8) having TBI, (9) family member with TBI, (10) friend with TBI, or (11) other sources.

Data Collection

The initial open-ended assessment was conducted on a convenience sample of 37 pre-medical students of a "Biochemistry" course at a Midwestern research-intensive university. Participants were not purposefully selected based on gender, ethnicity, and socio-economic conditions. Then the multiple choice assessment was conducted on 38 premedical students of another section of the same "Biochemistry" course. The entire

study design is presented on Figure 1. Both the assessments were conducted by using the research software "Qualtrics". No prior instruction was given to the students about brain injury either by the class instructor or by the researcher. Students answered both of the assessments online without any time limit. However, the total time was recorded for each student by the software to complete each assessment. Student response data were recorded onto Microsoft Excel spreadsheets.

Data Analysis

Item Analysis

A three-fold coding scheme was followed in item analysis of the TBIKT- (1) normal coding, (2) correcting for guessing, and (3) coding for misconception. First, for normal coding, each question on the TBIKT assessment was coded either as a "1" or a "0". Participants obtained "1" for a correct answer and a "0" for an incorrect answer. In the second stage, implementing a correction process for guessing, I coded any guessed answer (indicated by a reported CRI of 1, indicating "guessing") as "0" even though the answer is correct. In the third stage- coding for misconceptions, a misconception was coded as "1" and a correct conception was coded as "0". Here, a wrong answer with a confidence level of more than 2 according to the CRI index was considered as misconception.

After completion of the coding process, the reliability and validity of the items was quantified in order to filter the TBIKT into a final version by removing the items responsible for reducing the reliability and validity of the assessment.

Analysis of Open-Ended Responses and Interview Data

The open-ended responses were analyzed by an open coding process. According to Strauss (1990) open coding process has several steps: breaking down of data, examining, comparing, conceptualizing, and categorizing. There are several ways of proceeding with open coding which were used in this study.

Line by Line Analysis

This was a detailed type analysis which involved close examination of each phrase or even of each single word. Sometimes it was tedious to go for line by line analysis but very inspiring since it was generative. This was useful in getting the idea about what to focus on in the first version of the multiple choice assessment.

Coding by Sentence or Paragraph

This was useful in getting the major idea for each sentence or for each paragraph. This was useful when there were several defined categories. I applied this analysis for different sections of brain injury such as brain damage, coma, amnesia, and recovery.

Analysis of the Multiple Choice Assessment-TBIKT

Each item of the TBIKT was evaluated using p-values (for difficulty) and point-biserial correlations (for discrimination). The point-biserial correlations and the p-values were calculated using Microsoft Excel. Details on calculating these statistics are discussed in a previous section. The point-biserial correlations were calculated by using the following three steps:

1. Calculation of the total score for each student.

2. Calculation of the total score minus each item score for each student.

3. Finally calculation of the point-biserial correlation for each item using "Correl" function.

Item p-values were calculated by the following two steps:

1. Calculation of the total correct scores for each item.

2. Dividing the total correct scores for each item by the total number of students who answered that item.

Analysis of Misconceptions

The ultimate target of this study was to determine students' misconceptions about TBI. The TBIKT used a confidence tier to measure the misconceptions more accurately. Each question was coded either as 1 or 0, with 1 for a correct answer and 0 for an incorrect answer. A wrong answer with a confidence level of more than 2 according to the CRI index was considered as misconception for this study. The level of 10.0% or more incorrect responses was used to establish a misconception by several other researchers (e.g., Chandrasegaran, Treagust, & Mocerino, 2007; Odom & Barrow, 1995; Wang, 2004). There are some other ways to verify misconceptions, such as Romine et al., (2013) which used a chi-square test to identify student's misconceptions about influenza.

However, use of the CRI allows a deeper analysis. When a student chose "Guessing" or "Uncertain" in the CRI tier, that was not considered as misconception but lack of knowledge. Hasan et al., (1999) stated that: "Irrespective of whether the answer was correct or wrong, a low CRI value indicates guessing, which, in turn, implies a lack

of knowledge" (p. 295). On the contrary, when a student chose "Certain" and/or "Very Confident" in the CRI tier for his/her response of tier 1 that was considered as misconception meaning the student indicated knowledge which is contradictory to that which is scientifically accepted (Arslan, Cigdemoglu, & Moseley, 2012; Caleon & Subramaniam, 2010; Odom & Barrow, 2007). This contrasts with selection of a correct response with high CRI level indicating proper knowledge about the item.

RESULTS

Table11.

Discrimination, difficulty, and misconception analysis for the items of TBIKT.

Items	Normal coding (Alpha=0.62)		Correction for guessing (Alpha=0.74)		Difference of P values	Difference of Point Bis.	Misconceptions (Alpha=0.77)	
	Difficulty (P- value)	Discrimination (Point Bis.)	Discrimination (P- value)	Difficulty (Point Bis.)			P- value	Point Bis
Q1	0.895	0.329	0.842	0.485	0.053	0.156	0.053	0.090
Q2	0.579	0.316	0.500	0.343	0.079	0.027	0.079	0.253
Q3	0.921	0.051	0.895	0.223	0.026	0.172	0.000	NA
Q4	0.474	0.209	0.474	0.229	0	0.02	0.368	-0.001
Q5	0.553	0.148	0.500	0.069	0.053	-0.079	0.105	0.100
Q6	0.579	0.088	0.579	0.126	0	0.038	0.105	0.065
Q7	0.432	0.219	0.368	0.123	0.064	-0.096	0.211	0.123
Q8	0.658	0.190	0.605	0.393	0.053	0.203	0.132	0.432
Q9	0.211	-0.138	0.158	0.023	0.053	0.161	0.421**	0.221
Q10	0.474	0.273	0.447	0.374	0.027	0.101	0.342	0.291
Q11a	0.421	-0.151	0.368	-0.040	0.053	0.111	0.316	0.524
Q11b	0.316	-0.390	0.289	-0.173	0.027	0.217	0.342	0.557
Q11c	0.184	0.222	0.158	0.255	0.026	0.033	0.447**	0.610
Q11d	0.368	0.372	0.368	0.442	0	0.07	0.342	0.545
Q12	0.541	0.388	0.526	0.283	0.015	-0.105	0.289	0.153
Q13	0.605	0.348	0.605	0.350	0	0.002	0.316	0.184
Q14	0.500	0.036	0.447	-0.002	0.053	-0.038	0.263	0.209
Q15	0.895	0.228	0.868	0.204	0.027	-0.024	0.079	0.015
Q16	0.789	-0.231	0.763	-0.215	0.026	0.016	0.184	0.030
Q17	0.974	0.265	0.974	0.241	0	-0.024	0.000	NA*
Q18	1.000	NA*	0.947	-0.112	0.053	NA*	0.000	NA*
Q19	0.421	0.202	0.395	0.446	0.026	0.244	0.395**	-0.13
Q20	0.684	0.239	0.553	0.317	0.131	0.078	0.132	0.124
Q21	0.421	0.202	0.342	0.233	0.079	0.031	0.263	0.284
Q22	0.395	0.118	0.316	0.295	0.079	0.177	0.316	0.022
Q23	0.895	0.128	0.816	0.287	0.079	0.159	0.053	0.185
Q24	0.289	-0.054	0.289	-0.100	0	-0.046	0.500**	0.059
Q25	0.737	0.350	0.711	0.632	0.026	0.282	0.079	0.074
Q26	0.500	0.134	0.421	0.149	0.079	0.015	0.316	0.512
Q27	0.500	0.159	0.447	0.198	0.053	0.039	0.237	0.289
Q28	0.711	0.006	0.658	0.217	0.053	0.211	0.105	0.118
Q29	0.974	0.265	0.921	0.346	0.053	0.081	0.000	NA*
Q30	0.079	-0.041	0.079	-0.025	0	0.016	0.500**	0.578
Q31	0.243	0.048	0.216	-0.030	0.027	-0.078	0.432**	0.417
Q32	0.368	0.266	0.297	0.470	0.071	0.204	0.324	0.543
Q33	0.270	0.158	0.243	0.159	0.027	0.001	0.243	0.334
Q34	0.405	-0.125	0.324	0.081	0.081	0.206	0.351	0.256
Q35	0.730	0.080	0.676	0.243	0.054	0.163	0.216	0.304
Q36	0.973	0.099	0.838	0.357	0.135	0.258	0.000	NA*
Q37	0.838	0.462	0.757	0.164	0.081	-0.298	0.027	0.193
Q38	0.622	0.219	0.486	0.259	0.136	0.04	0.216	0.458
Q39	0.833	-0.098	0.649	0.069	0.184	0.167	0.108	0.107
Q40	1.000	NA*	0.892	0.392	0.108	NA*	0.000	NA*

*Undefined. The variance is "0" for these items.
** Items with highest misconceptions (above 0.40).

RQ1. To what extent does the TBIKT a valid and reliable measure for pre-medical students' understanding of TBI?

Table 11 contains item difficulty and discrimination statistics for the three coding schemes (normal coding, correction for guessing, and coding for misconceptions). The item difficulty (p-value) of the TBIKT was found with a range from 0.079 to 1.0. The item discrimination (Point Bis.) of the TBIKT was found positive for 35 items among 43 items with a range from -0.390 to 0.462. Thus, the items of the TBIKT had a wide range of item difficulty and item discrimination indicating the validity of many items on the assessment. In addition, by factor analysis, the calculated reliability for items of factor 1 and factor 2 were 0.71 and 0.67 respectively.

Item Difficulty

When normal coding is used, the easiest items of the TBIKT were Q18 and Q40 (Table 11), for both of these items the p-value was 1.0 which means all the students were correct in these 2 items. So, the variance is 0 for these 2 items. Other easier items of the assessment which have p-values greater than 0.89 include Q1, Q3, Q15, Q17, Q23, Q29, and Q36 (Table 11). There were several difficult items which have p-values lower than 0.30, which were Q9, Q11c, Q24, Q30, Q31, and Q33 (Table 11).

According to Table 11, after taking participants' confidence into consideration for item difficulty analysis, the p-value decreased most for items Q38 (0.136) and Q39 (0.184). So, the most influence of guessing on item difficulty was found for these two

items. That means these were the items where people had most tendency for guessing. On the contrary, no influence of guessing was found for items Q4, Q6, Q11d, Q13, Q17, Q24, and Q30 (Table 11). For remaining items, the p-value decreased very little due to the influence of guessing.

Item Discrimination

Items with the highest point-biserial correlation values were Q1, Q2, Q11d, Q12, Q13, Q25, and Q37 with a range from 0.316 (Q2) to 0.462 (Q37). These are the most productive items of the assessment for separating students of high and low ability. It can be said that students who got high scores on the overall test tended to get the item right and the students who got low scores on the overall test tended to get the item wrong.

There were 8 items among 43 items with negative point-biserial correlations Q9, Q11a, Q11b Q16, Q24, Q30, Q34, and Q39 with a range from -0.231(Q16) to -0.041 (Q30). This indicates that students with low scores on the overall test got these items right and students with high scores got the items wrong. These are the items requiring further revision.

Since the point-biserial correlations was calculated by dividing by the variance of the set of data and something divided by 0 is undefined, it was impossible to calculate point-biserial correlations for the 2 items (Q18 and Q40) with p-values of 1 or 0. These items should be discarded in future implementations of the TBIKT as they yield no quantitative information about the knowledge of pre-medical students.

Factor Analysis

The intension of conducting factor analysis was to identify multiple latent variables within the TBIKT data set. The statistical software Stata was used for factor

analysis using the method of principal components with a Promax rotation. Since Promax rotation allowed the factors to be correlated, Promax rotation was useful for this analysis rather Varimax method for rotate loading. It is reasonable to expect that subscales for knowledge of TBI will be correlated.

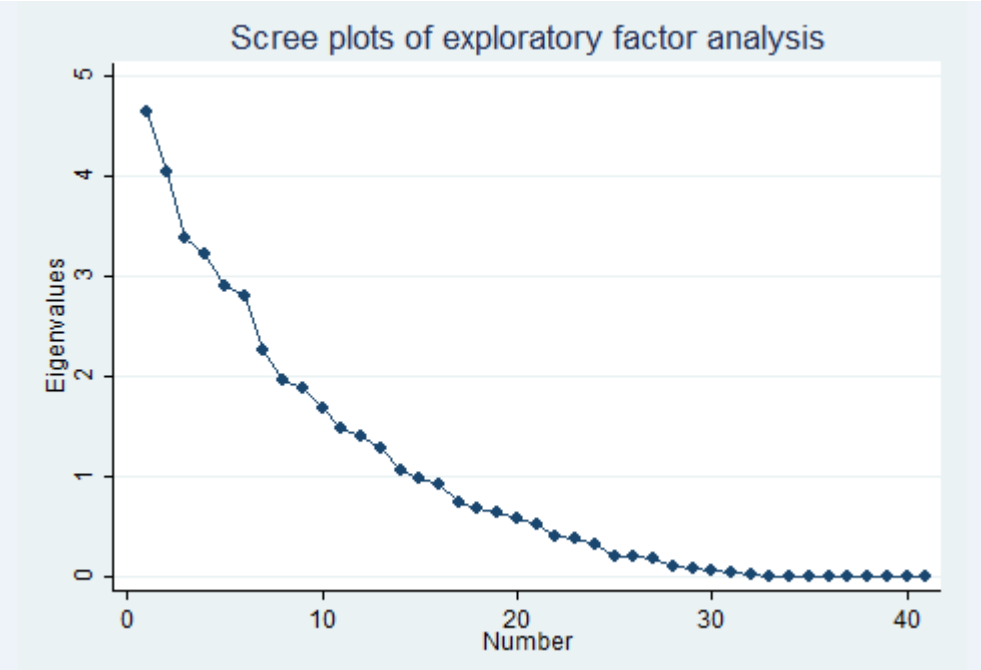

Figure 3: Scree plot of exploratory factor analysis for the TBIKT data.

Since principal component analysis and factor analysis are the methods to reduce data, it is important to retain an appropriate number of factors based on the trade-off between simplicity and completeness. Simplicity means retaining as few as possible factors and completeness means explaining most of the variation in the data. The "Scree test" (Cattell, 1966) was used to determine the number of factors for the TBIKT assessment. According to the "Scree test", the eigenvalues of the correlation matrix were plotted in descending order. Since, a number of factors should be used which is equal to the number of eigenvalues that occurred just before the last major drop in magnitude, I

rotated the principal components up to 5 components to get the most suitable and as few as possible number of factors. I found the 2 factor rotation yielded the most reliable set of items with the greatest Cronbach's alpha values.

Table12.

Item's position and tendency after 2 factor rotation.

Factor	Items with positive tendency	Items with negative tendency
1	Q1, Q2, Q3, Q4, Q5, Q8, Q10, Q11d, Q12, Q13, Q14, Q17, Q19, Q20, Q24, Q25, Q27, Q28, Q29, Q37, and Q38	Q9, Q11b, and Q23
2	Q6,Q 7, Q15, Q21, Q22, Q26, Q31, Q32, Q34, Q35, and Q36	Q11a, Q11c, Q16, Q30, Q33, and Q39

Among the 41 items, a total of 32 items showed positive tendency and 9 items showed negative tendency after rotation (Table 12). These 32 items are suggested for use in a revised TBIKT (Appendix B) for future studies. The Cronbach's alpha values for the 32 items with positive tendency for factor 1 and factor 2 were 0.71 and 0.67 respectively. The remaining 9 items, which had negative tendency had an alpha value of 0.36. To increase the reliability of a shorter revised version of the TBIKT, these 9 items can be either discarded or added to the qualitative assessment. However, with respect to the main latent dimensions on the TBIKT, these are not useful for generating a reliable quantitative measure.

In the 32-item revised version of the TBIKT, the Cronbach's alpha value for 2 combined factors before correction for guessing was 0.70 and for the data after correcting for guessing was 0.77. This means correcting for guessing increased the reliability of the

revised assessment. Considering guessed responses incorrect not only increased the reliability of the revised TBIKT (Appendix B) but also increased the validity of the test. According to Classical Test Theory elimination of the error components from total score of a set of data increase the validity of a test. Guessed-correct or guessed-incorrect responses are not the students' true conceptions, so by considering guessed responses incorrect, the TBIKT measured misconceptions more precisely. The individual alpha values of the items of factor 1 and factor 2 with positive tendency after correction for guessing were 0.72 and 0.71 respectively.

The items in factor 1 have some common traits, such as causes of TBI, types of TBI, effects of TBI, treatment of TBI, things to do or not to do after TBI, and the susceptibility to a second blow after TBI. The common traits for factor 2 include topics regarding the recovery process and coma. The items with negative tendency of factor 1 and 2 have the traits of physical and emotional symptoms of TBI, amnesia, and severity of TBI. These contain important information, but do not fit with the TBIKT's main latent dimensions.

Table13.

Structure matrix of factor 1(reliability=0.71) and factor 2 (reliability=0.67) items.

Variables	Factor1	Factor2
Q1	0.0895 *	-0.0431
Q2	0.2675 *	0.1972
Q3	0.1806 *	0.1701
Q4	0.2023 *	0.0314
Q5	0.4465 *	0.3127
Q6	0.0790	0.4444 **
Q7	0.2530	0.5775 **
Q8	0.5873 *	0.1880

Q9	-0.2442	0.0527 ***
Q10	0.4403 *	-0.3463
Q11a	-0.2695	-0.5525 ***
Q11b	-0.3892	-0.3523 ***
Q11c	0.2179	-0.4319 ***
Q11d	0.4542 *	-0.1481
Q12	0.4173 *	-0.1313
Q13	0.6009 *	0.0721
Q14	0.3289 *	0.2235
Q15	0.1355	0.1647 **
Q16	-0.0248	-0.4568 ***
Q17	0.7155 *	-0.1497
Q19	0.2223 *	0.2044
Q20	0.1981 *	-0.1420
Q21	0.0008	0.3421 **
Q22	0.0249	0.4489 **
Q23	-0.1776	-0.0226 ***
Q24	0.3250*	-0.2718
Q25	0.5251 *	0.0609
Q26	-0.1151	0.1369 **
Q27	0.1777 *	0.0628
Q28	0.3563 *	-0.0385
Q29	0.7155 *	-0.1497
Q30	- 0.0514	-0.3678 ***
Q31	- 0.3109	0.5626 **
Q32	- 0.0783	0.6084 **
Q33	0.1235	-0.1788 ***
Q34	-0.3030	0.6317 **
Q35	0.0332	0.1793 **
Q36	0.1265	0.4100 **
Q37	0.6155 *	0.0361
Q38	0.3394 *	-0.2787
Q39	0.2466	-0.4405 ***

* Items of factor 1
**Items of factor 2
***Items are not useful for any of the factors.

RQ2. How does the level of misconceptions expressed in the items relate to the difficulty of the items?

The level of misconceptions was higher for difficult items and lower for the easier items. On the misconception scale, the p-value for items Q24 and Q30 was found

to be 0.50, which means 50% of the participants had misconception on both of the items. That is rational as these items were difficult according to their p-values (0.289 and 0.079 respectively) before correction for guessing. On the contrary, for the easier items such as Q1 and Q3 (p-values were 0.895, and 0.921 respectively), the misconceptions were expressed at rates of 5% and 0% respectively.

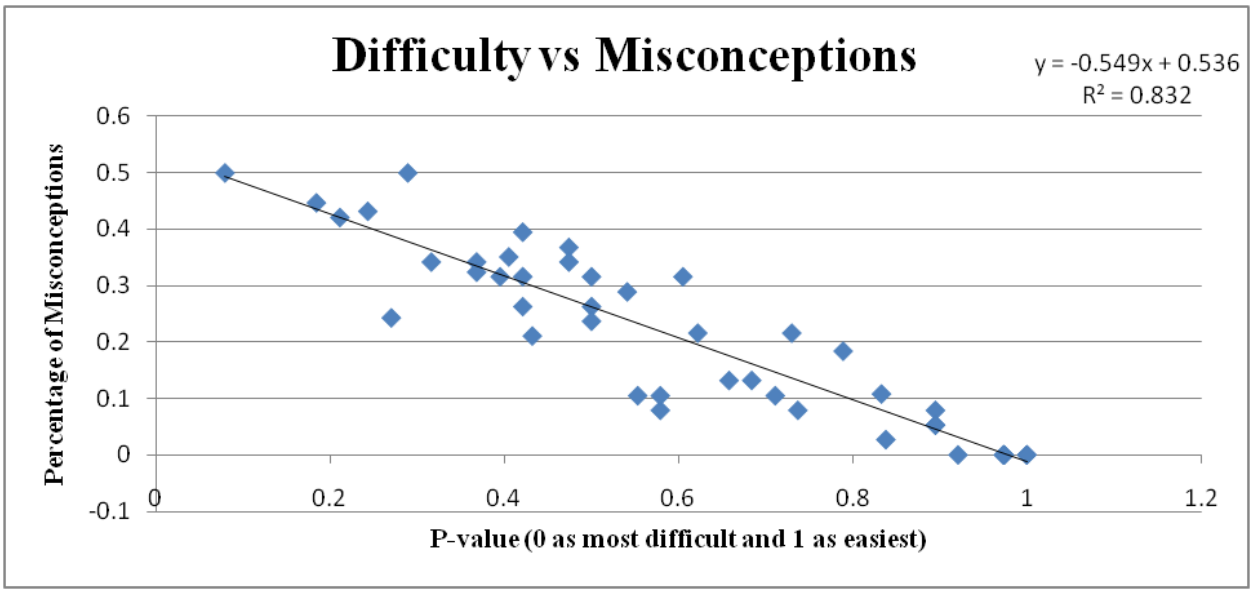

***Figure 4*:** Relation between item's difficulty and item's misconception rate.

The calculated correlation between the misconception p-values and normal coding p-values was -0.91, which means the item difficulty and misconception for an item had a high inverse relationship. The negative correlation indicates that the two variables have inverse relationship- the easier the item, the fewer misconceptions participants tended to have on it. This provides important evidence for the integrity of both the knowledge and misconception scales. The high inverse relationship also shows the TBIKT is valid, because the items were not favoring to the students of low ability; it's

expected that the students with low ability will select more wrong answers for the difficult items.

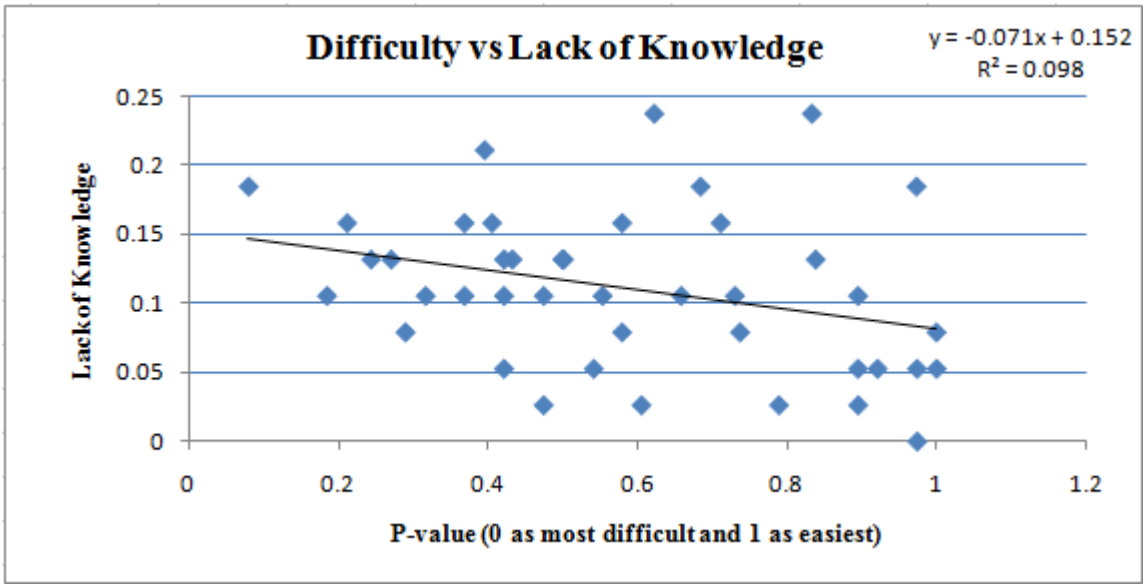

***Figure 5*:** Relation between item's difficulty and participants' lack of knowledge.

The calculated correlation between the difficulty of items and the proportion of students expressing lack of knowledge on each item was -0.31, which means the item difficulty and proportion of participants expressing lack of knowledge for an item had a low inverse relationship. Figure 5 also shows that the two variables do not have a close relationship. This means, with the decrease of an item's difficulty, students' tendency to express confidence on the item increases.

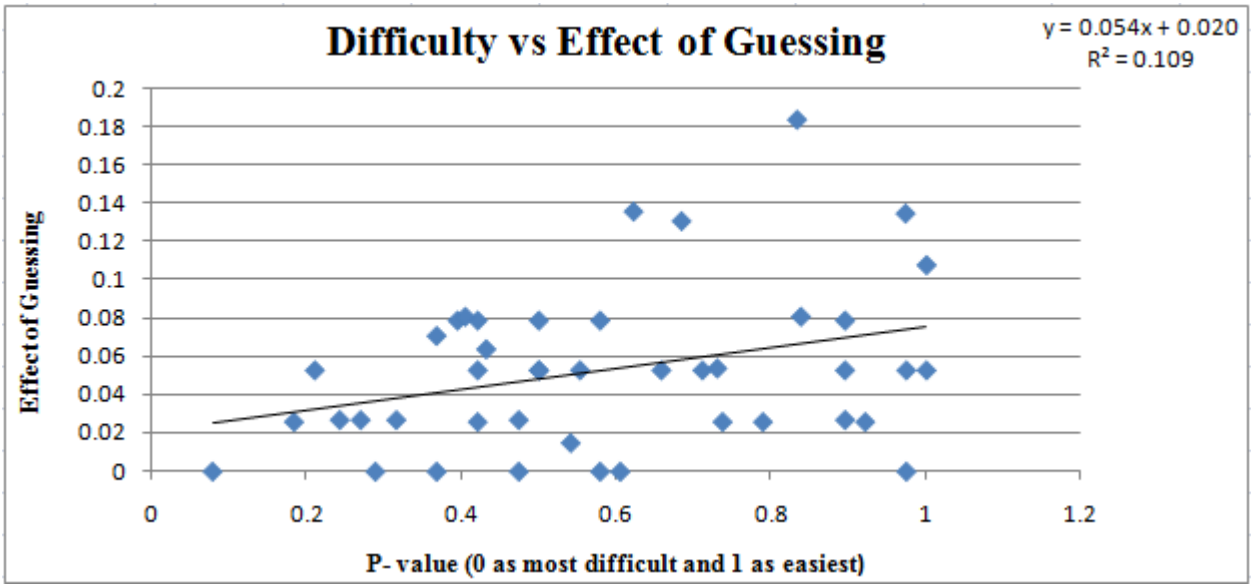

***Figure 6*:** Relation between item's difficulty and effect of guessing.

The correlation between the difficulty of items and the effect of guessing was 0.33, which means the item difficulty and the effect of guessing for an item had a low positive relationship. Figure 6 shows that item difficulty has very little influence on students' tendency to guess on correct responses. The slight positive relationship is due to the increased prevalence of correct responses on the easier items, meaning there is more opportunity for the penalty for guessing to be implemented.

Figures 4-6 show that items' difficulty had an influence on students' misconceptions but not on their lack of knowledge and effect of guessing. This means the identification of misconceptions was largely separate from the influence of students' lack of knowledge and guessing, which illustrates the validity of the TBIKT, since measuring the misconceptions about TBI precisely was its goal.

RQ3. What are the most prominent misconceptions that premedical students have about TBI?

There were 5 items (Q9, Q11c, Q24, Q30, and Q31) on which 40% or more students expressed a misconception. One another item (Q19), 39.5% of students expressed a misconception. Distracter analysis for these 6 items are discussed and equated with the results of written responses on the open-ended assessment.

Item Q 9. Which of the following is a common physical symptom of TBI?

The four responses options were:

a. Lack of appetite. (https://www.nlm.nih.gov/medlineplus/ency/article/003121.htm)

b. Back pain. (http://www.webmd.com/back-pain/history-and-physical-exam-for-low-back-pain)

c. Trouble controlling bladder. (5^{th} PKS)

d. Problems in planning. (6^{th} PKS- cognitive symptom)

The identified misconception rate for this item was 42.1%. Here the correct answer is "c". A total of 15 (39.47%) participants out of 38 choose "d" with a CRI>2. The distracter "d" "Problems in planning" is actually a cognitive symptom according to the 6^{th} PKS. Since 39.47% of the students identified the emotional symptom instead of the correct physical symptom as the correct answer for this item with high confidence, this represents: *Misconception about physical and cognitive symptoms.* (5^{th} and 6^{th} PKSs, Table 8)

The written responses to the open-ended assessment (Appendix C) of this research also revealed a potential level of misconceptions among the participants on items of physical, cognitive, and emotional symptoms of TBI. A total of 25 responses in

3 items (2, 3, and 4) (Table 21) were expressed by students as misconceptions about physical, cognitive, and emotional symptoms of TBI through the qualitative open-ended data. For example: item 2 of the qualitative assessment asked "What kind of physical problems are commonly associated with traumatic brain injury?", the 2nd response "loss of mental acuity and cognition" was actually cognitive symptom, indicating a misconception about physical and cognitive symptoms.

Q 11. Which is/are common emotional symptom(s) associated with TBI?

(5th and 7th PKS)

The four response options were:

a. Impaired communication skills. (6th PKS- cognitive symptom)

b. Forgetting known people. (6th PKS- cognitive symptom)

c. Slow thinking. (6th PKS- cognitive symptom)

d. Nightmares. (7th PKS)

The percentage of misconceptions for the 3rd option of item 11 was 44.7%. In this item, students had the freedom to choose more than a single distracter. Since the correct answer is "d", choosing any other option was considered as incorrect for that specific distracter. A total of 17 (44.74%) students chose "slow thinking" (c) as an emotional symptom of TBI with CRI>2. Failure to identify "slow thinking" as a cognitive symptom represents: *Misconceptions about emotional and cognitive symptoms of TBI* (6th and 7th PKSs, Table 8)

In the written responses to the open-ended assessment (Appendix C), a total of 25 responses in 3 items (item 2, 3, and 4) were expressed as misconceptions about

physical, cognitive, and emotional symptoms of TBI (Table 21 & 22). For example, 16th response of question 4 mentioned "depending on the trauma: PTSD, memory, cognitive functions, speech, hearing and attention" (Table 22) are emotional symptom of TBI, which are actually cognitive and physical symptoms of TBI.

Q 19. Which statement is FALSE about a man who has gone into a coma due to a blow to the head?

The four response options were:

a. Lost consciousness is an indication of severe TBI. (Faul et al., 2010: Patients with amnesia for a long post-injury period are likely suffering from severe TBI.)
b. It is likely he may wake up from the coma without any lasting effects. (16th PKS)
c. He may lose some previous memory after waking up from the coma. (6th PKS)
d. He may lose cognitive ability after waking up from the coma. (6th PKS)

There were 39.5% of the students expressing misconceptions found in this item. The "false" statement for this item is "it is likely he may wake up from the coma without any lasting effects" (b). Eight (21.05%) students selected "lost consciousness is an indication of severe TBI" (a) and 4 (10.53%) students selected "he may lose cognitive ability after waking up from the coma" (d) as the "false" statement with a CRI>2. This represents students' misconceptions on: *a person with TBI may wake up from coma without any lasting effects*.

Q 24. Which memories are more difficult to remember for a person with TBI?

The four response options were:

a. Events following the brain injury. (18th PKS)

b. Events preceding the brain injury.

c. Events before and after the brain injury.

d. TBI can improve recollection of long term memories. (13th OEQ, 25th response)

The identified proportion of students expressing misconceptions on these responses was 50%. Here the correct answer is "events following the brain injury are more difficult to remember for a person with TBI" (a). Among the 38 participants 11 (28.95%) chose "events preceding the brain injury" (b) and 8 (21.05%) choose "events before and after the brain injury" (c) as the correct answer with a CRI>2. This represents students' misconception about *most greatly affected memories due to TBI.* (18th PKS, table 8).

The written responses to the open-ended assessment (Appendix C) also revealed 5 responses in item 13, which addressed memory loss, displaying students' misconceptions about largely affected memories. For example, the 9th response of the 13th open-ended question mentioned "a TBI could cause a person to lose short-term memory yet retain memories from childhood" (Table 24).

Q 30. When a person with TBI is in the recovery process-

The four response options were

a. The person needs to do physical exercise and take moderate rest. (26th PKS)

b. He/she needs to take rest all of the time. Even a little physical exercise may be harmful at this stage. (26th PKS; 17th OEQ, 4th response)

c. The person needs to do a large amount of physical exercise.

d. Most patients should complete 30 minutes of exercise and get 8-10 hours of sleep each day. (17th OEQ, 4th response)

The calculated misconception rate for item Q30 was 50%. The correct answer for this item is "a person with TBI is in the recovery process needs to do physical exercise and take moderate rest" (a), but 12 (31.58%) students chose "d"- "Most patients should complete 30 minutes of exercise and get 8-10 hours of sleep each day" and 6 (15.79%) students chose "b"- "He/she needs to take rest all of the time. Even a little physical exercise may be harmful at this stage" as the correct answer with a CRI>2. These findings represent students' misconceptions about *required rest and physical exercise for recovery from TBI.*

The written responses to the open-ended assessment (Appendix C) also found 4 responses among 37 participants in item 17 addressing the same issue. For example, the 4th response of item 17 mentioned "following a traumatic brain injury, it is essential to receive the same amount of sleep so that the brain can recover, and to exercise mentally, physical exercise is more dangerous to the person" (Table 23).

Q 31. Jessica, a 10 year old girl, had a severe brain injury one year ago. Which of the statements below about her recovery is true?

The four response options were:

a. She can be completely cured if she puts in enough effort. (18th OEQ, 4th response)
b. Young people can heal faster; she will likely be completely cured within 1-2 years. (18th OEQ, 12th response)
c. She will likely never be completely cured. (27th PKS)

d. She can be completely cured if enough neurons are recruited to take over the loss of the damaged ones. (18th OEQ, 2nd response)

There were 43.2% of students expressing misconceptions on item Q 31. The correct answer is "Jessica will likely never be completely cured after the TBI " (c), but 11 (28.95%) students selected option "Jessica can be completely cured from TBI"(d) and 5 (13.15%) students selected option "Young people can heal faster from TBI" (b), with CRI>2. These represent students' misconceptions about recovery from TBI. They are endorsing misconceptions on the following statements: *full recovery is possible from severe TBI,* and *young people can heal faster from TBI.*

The written responses to the open-ended assessment (Appendix C) also found 14 students among 37 had misconceptions about the same issue in item 18. For example, the 33rd response of the qualitative part mentioned "over time with the right therapy, a TBI could be cured nearly 100%" (Table 18).

Table14.

List of prominent misconceptions identified by TBIKT.

Number	Misconceptions	Percentages
1	Problem in planning is a physical symptom of TBI.	39.47
2	Slow thinking is an emotional symptom of TBI.	44.74
3	A person with TBI may wake up from coma without any lasting effect.	39.50
4	Lost consciousness is not an indication of severe TBI.	21.05
5	Events following the brain injury are easier to remember than the events preceding the brain injury for a person with TBI.	50.00
6	Events preceding the brain injury are most difficult to remember for a person with TBI.	28.95
7	Most TBI patients should complete 30 minutes of exercise and get 8-10 hours of sleep each day.	31.58
8	A TBI patient needs to take rest all of the time. Even a little physical exercise may be harmful.	15.79

9	A TBI patient is likely to be completely cured after the TBI.	28.95
10	Young people can heal faster from TBI.	13.15

RQ4. Through what resources have pre-medical students acquired information about traumatic brain injury?

The most frequently cited 4 sources were newspapers (55.26%), TV programs (50%), professionals (50%), and movie/drama (44.73%). Other sources were family (28.95%), magazines (23.68%), and having a friend with TBI (23.68%).

Table15.

Frequencies and percentages of different sources of TBI knowledge.

Sources	Frequency	Percentage
Newspapers.	21	55.26
TV programs	19	50
Professionals	19	50
Movie/drama	17	44.73
Friends	15	39.47
Family	11	28.95
Magazines.	9	23.68
Friend with TBI.	9	23.68
Family member with TBI.	6	15.79
Personal experience	4	10.52

DISCUSSION

Summary of the Study

The purpose of this study was to develop and validate a multiple choice assessment instrument (TBIKT) to measure the premedical students' misconceptions about traumatic brain injury. The theoretical framework introduced by Treagust (1986, 1988, and 1995) was followed for the development of the TBIKT in three stages: define the content clearly, investigate previous research on people's misconceptions about traumatic brain injury, and develop a multiple choice assessment. The other studies (Gouvier et al., 1988; Willer et al., 1993; Guilmette & Paglia, 2004; Hux et al., 2006; Ernst et al., 2009; Evans et al., 2009; and Block et al., 2014) focusing on the misconceptions about TBI did not concentrate on defining the content. Moreover, these studies did not conduct any pilot trial before conducting the final assessment. Going through the steps as Treagust (1986, 1988, and 1995) suggested for developing an assessment yields a more complete theoretical understanding as opposed to going straight towards conducting an assessment or interviewing participants. This gives the assessment creator a deeper knowledge about a topic to the end of creating an assessment with high validity.

In this study, there were 28 PKSs to define the content on TBI and a total of 9 primary research papers were included as the resources of previous study conducted on TBI. There was a qualitative assessment with twenty Open-Ended Questions (Appendix

C) used for collecting data on students' misconceptions about TBI, which eventually helped to develop the multiple choice TBIKT. A certainty of response index was included with the TBIKT to increase the validity of the assessment by eliminating confounding due to guessing. Data from the TBIKT were used to identify students' misconceptions and the validation of this instrument aided in developing a revised version of the TBIKT that can be used in future research. The TBIKT (Appendix A) had 40 multiple choice items with an item (Q11) where students had the option to choose up to 4 distracters, that made the total items of the TBIKT as 43.The revised TBIKT (Appendix B) was finalized with 32 items after item and factor analysis of the data was completed.

The ultimate target of this study was to identify the level of misconceptions that pre-medical students are endorsing about TBI. Students of a "Biochemistry" course, which is a prerequisite course for medical students at this university, were chosen as the sample of this research. There were two sections of this course; none of these sections had common students. First, the open-ended assessment (Appendix C) was conducted on one section and then the TBIKT was conducted on another section, so students who participated in the TBIKT had no prior exposure to the open-ended assessment of TBI.

The Validity and Reliability of the TBIKT

In the literature search, most of the studies were found not to be concerned about assuring reliability and validity of the assessments. They simply calculated the percentages of misconceptions from a 2 or 4 point Likert scale. However, according to

Classical Test Theory each assessment score has a true component and an error component. To assure that the assessment is measuring the misconceptions accurately and precisely, it needs to go through reliability and validity testing to understand the relative contribution of true and error components in students' observed scores.

To ensure accuracy, both the open-ended assessment and the final multiple choice TBIKT were sent to experts in the field of TBI and education for content validation. Suggestions of the experts were integrated to make the assessment valid with regards to content.

The item level construct validity was analyzed with respect to item difficulty and item discrimination. The item difficulty was measured by calculating the p-values of each item. The p- value of the TBIKT was varying from 0.079 to 1.0, mostly concentrating on 0.5. So, it can be said that the TBIKT had items of low to high difficulty, which was one indicator of a valid assessment.

A CRI was added to each question of the TBIKT to identify the items on which students did the most guessing. There were 2 such items (Q38 and Q39) found which were most influenced by the conjecture of students. These items should be taken into consideration for rewording before conducting the assessment again to test whether the wording was making wrong or vague sense to the students.

The item discrimination of the TBIKT was quantified by calculating the point-biserial correlation of each item. A positive point-biserial correlation is an indication of a productive item which can precisely distinguish the students of high and low ability. The TBIKT had 35 positive items among the total 43 items with a range from 0.006 to 0.462,

mostly concentrating on 0.2. The remaining 8 items had negative point-biserial correlations. Five out of 8 items also showed the negative tendency in the factor analysis, which confirmed their characteristic as weak items responsible for low reliability. The remaining 3 items (Q24, Q30, and Q34) need to be either eliminated or further considered for rewording and distracter analysis. Among these 3 items, 2 (Q24, Q30) were found with maximum misconceptions (50%). The item Q30 might have problematic distracters, specifically distracter "d" which misled most participants (31.58% misconceptions). These two items can be added as True/False items in future study. Since the item Q34 was a True/False item, it might have the problem of misleading wording.

Items were clustered into subscales using factor analysis and reliability of these subscales and the whole test was calculated using Cronbach's alpha. The initial alpha value was set as 0.70 for the TBIKT. For the 2 component factor rotation, there was a total of 32 items which showed positive tendency and 9 items showed negative tendency after rotation (Table 12).For the 32 items of positive tendency, the Cronbach's alpha value for 2 combined factors for the data before correction for guessing was 0.70 and for the data after correction for guessing was 0.77. This illustrates that taking the guessing into consideration improved the reliability of the assessment. Hence, for the future use of this assessment, researchers should integrate the CRI into each item to get more accurate and reliable results. The Cronbach's alpha values for 32 items with positive tendency for factor 1 and factor 2 were 0.71 and 0.67 respectively. Both the factors were distinguished by different latent traits. Factor 1 includes causes of TBI, types of TBI, effects of TBI, treatment of TBI, things to do or not to do after TBI, and the susceptibility to a second

blow after TBI. Factor 2 includes items addressing recovery processes and the effects of coma.

There were total 11 True/False items in the TBIKT (APPENDIX A). Five of them were easy items (p-value > 0.89), and no item was difficult (p-value < 0.30). Among the 11 True/False items, 4 had 7% to 18.4% influence of guessing. For the remaining 7 True/False items, the influence of guessing was varied from 2% to 8%. Since, the maximum influence of guessing was 18.4% on item Q39 of the TBIKT and 18 items had 0% to2.9% influence of guessing, I can conclude that the influence of guessing on the True/False items can be considered as significant. Addition of more answer choices may decrease the likelihood of guessing in future use of the TBIKT.

The productivity of an assessment depends on how accurately it can measure what it is actually intending to measure in different conditions and on different samples. The TBIKT was successful in measuring the premedical students' misconceptions about traumatic brain injury with reliable test results. A version of the TBIKT revised according to the findings in this study will be more useful for future investigations. I also recommend administering the TBIKT to pre-medical students at other universities to build a case for generalizability of my findings, including the major misconceptions held by students as well as the psychometric behavior of the assessment itself.

Limitations of the Instrument and Recommended Use

To use the TBIKT effectively in the future, several factors should be taken into consideration. The TBIKT can be characterized as a multiple choice assessment that measures premedical students' knowledge of many concepts around TBI. In the data

analysis, the calculated p-values of the TBIKT suggest that this is a suitable assessment for medical and premedical students, but may be an easy instrument for certified medical doctors and a difficult one for high school level students or the general public. Moreover, the TBIKT may work reliably in drawing conclusions about misconceptions about TBI outside of the United States when it is conducted on students of equivalent level of education, and in areas where the causes, symptoms, and treatments of TBI are similar to those in the United States. However, the validity and reliability should still be assessed before using the TBIKT to draw conclusions. The acceptable reliability of the TBIKT (0.77) suggests that it will behave reliably for comparing different groups of participants when used as a single scale, but may not be the ideal assessment for individual comparisons. For individual comparison, additional questions need to be added to improve the reliability to above 0.8.

While collecting data, it was assumed that students know what TBI is. Students might have heard about concussion, but it is possible that students might not know TBI is concussion. In the additional section of the TBIKT, which asked about students' sources of knowledge about TBI, there was no "none" option to chose, which forced the students to choose source/s from the list. This should be kept in mind when interpreting conclusions from this study regarding sources where students learned about TBI. This said, it is noteworthy that the results of this study bear remarkable similarity to Gouvier et al.'s (1988) study.

TBI Misconceptions

There have been several studies conducted on misconceptions about TBI which were discussed in the literature review section of this research. However, none of the research was conducted on the premedical students who are going to enter into medical school and they did not use validated assessments. The TBIKT identified several misconceptions prevailing among premedical students. Students showed misconceptions in identifying physical, cognitive, and emotional symptoms of TBI. It was quite surprising that 52.63% students selected "problems in planning" (item Q9) as a physical symptom, which is actually a cognitive symptom of TBI. A total of 78.95% students had the understanding that "slow thinking" (item Q11) is an emotional symptom of TBI, which is actually a cognitive symptom. Students also had misconceptions about coma as a consequence of TBI. This study found 39.5% of students stated that it is likely a TBI patient may wake up from the coma without any lasting effects (item Q19). Several previous studies also found people's misconceptions on this statement. Ernst et al., (2009) found 34.8% of pre-nursing students had the same misconception. These two groups of students of two different studies are almost at the same education level and also carrying almost the same level of misconceptions about the effect of coma due to TBI. These identified misconceptions need to be dispelled before the premedical and pre-nursing students enter the medical profession. Further, half of participants expressed misconceptions on item Q30 where students had the misconception that a TBI patient needs to take rest all of the time, and that even a little physical exercise may be harmful. Ernst and colleagues' (2009) research on pre-nursing students also found 43.9% of their participants had a similar misconception. The findings of these two studies show that the

proportion of misconceptions on required amount of rest and physical exercise of a TBI patient while in recovery is greater in premedical students than the pre-nursing students. Next, 43.2% premedical students had the misconception that a complete cure of TBI is possible. Ernst et al., (2009) found 65.2% of pre-nursing students had this misconception. Comparison of the findings of these two studies shows premedical students had a lower proportion of misconceptions about the complete cure of TBI than pre-nursing students.

The identified misconceptions on the open-ended responses helped to prepare the TBIKT. The most dissimilarity was found between the calculated misconceptions of these two assessments on item Q20 of the TBIKT with item 11 of the open-ended assessment. While the open-ended assessment (Appendix C) found a rate of 45.95% misconceptions on the statement "a TBI patient does not concern him/herself about what is going on his/her surroundings when in a coma", the TBIKT found 13.2% misconceptions on the same statement. Ernst et al., (2009) also found 33.3% misconceptions on this statement of coma among pre-nursing students. This discrepancy may result from the distracters on item Q20 helping the students to get the right answer by process of elimination.

Consequences of Misconceptions and Recommendations

If a TBI patient carries these misinterpretations about the symptoms, coma, and recovery process of TBI, these may lead to negative consequences such as exacerbating the recovery process and making it more difficult for the patient to reintegrate into society (Guilmette & Paglia, 2002). If the people involved in the medical profession have these misconceptions, they could easily make the condition worse for the patients. For

example, if people have the misconception that “a TBI patient can be completely cured”, (item Q31) and find the patient is not doing so, they may start blaming the patient for not trying properly to be fully recovered or themselves for failing to cure the patient completely. However, for these misconceptions to be addressed and removed in pre-medical students, a measurement tool is needed to uncover these misconceptions before instruction; hence the need for the TBIKT. This study and the measurement tool it provides could be useful for health educators towards detecting and addressing misconceptions about TBI in premedical students.

Limitations of this Study

Despite this study’s importance, it also has important limitations that should be discussed. First, this study involved only students of a required premedical course during the fall semester of 2015. While this was intended, it also limits the generalizability of the TBIKT to different samples and environments. Revalidation is recommended in future research on different types of students including students at different geographic locations and academic levels. The sample size for the open-ended assessment (Appendix C) was 37 and for the multiple choice assessment TBIKT was 38. Use of Classical Test Theory to draw conclusions about a very specific group of students mitigated this limitation partially, but using a large sample size in future research will certainly improve the argument for validity, and would warrant use of more modern psychometric methods like Rasch analysis and Item Response Theory.

Second, participants were assumed to be future medical students, but all the students will not be able to reach medical school. Since this university does not have premedical school, I was forced to choose the required premedical course “Biochemistry”

for collecting data. Any future research which will be conducted on students in premedical school, or students in their first year of medical school, will enable validation of findings from this study.

Third, the identified misconceptions through the TBIKT are not the participants' only potential misconceptions about traumatic brain injury. They may have some other types of misconceptions too which may lead to increased risk of TBI, such as misconceptions about the efficacy of lifestyle choices like wearing seat belts or obeying traffic rules which lower the risk of TBI. Derivation of the PKS's from the Brain Injury Association of America, the Center for Brain Injury Research & Training, and Ernst et al., (2009), the strong literature base, and the rigorous content validation process strengthens the argument that the misconceptions addressed by the TBIKT are among the most important misconceptions about TBI in a medical context. The inclusion of items regarding some other topics related to TBI into the TBIKT may increase its efficacy to identify misconceptions for other groups of individuals.

Next, selection of an answer in the TBIKT may be influenced by a student's misunderstanding of scientific terms, confused wording or weak distracters. For example, item Q11 has 4 distracters and each distracter was counted as one item since students had the option to choose up to 4 answers for this item. According to Table 12, among these 4 distracters of Q11, 3 (a, b, and c) were clustered into negative tendency of 2 factors and reduced scale reliability. Further, distracters "a" and "b" had negative point-biserial correlations (Table 11), which indicates that these distracters are problematic and need revision and further content validation.

Finally, the participants did not have any time limit for the completion of the open-ended assessment (Appendix C) and the TBIKT. This may have influenced the results of the study because some participants might take a lot of time to think about the items while others might finish the assessment promptly without giving much thought to the questions. This limitation can be solved by fixing a time limit for completing the assessment. However, imposing a time limit would also add additional limitations such as reduced participation and the tendency for participants to rush through the assessment instead of taking the time to answer each item thoroughly.

Recommendations for Health Educators and Physicians

The findings of this research could be useful for school nurses, physicians, and instructors. Instructors would get an understanding about the general misconceptions prevalent in both the brain injured students and their peers. An instructor having this knowledge could make the classroom environment friendlier for a brain injured student. School nurses and physicians would also find this research useful toward better understanding the way of thinking of a brain injured student about his/her injury and recovery. Moreover, the authority of a disabled student's school that has brain injured students may use the data from this review to make the policy and regulations for the school by considering things that should be done to help individuals suffering from TBI.

This study may be useful for the health educators in two ways. In one way, they may use the findings of this research to set a curriculum which will give the medical students more specific knowledge about the potential misconceptions of TBI. In another way, they may use the revised TBIKT (Appendix B) to measure the misconceptions about TBI within a specific group of students or educators. The revised TBIKT

(Appendix B) has a total of 32 items with a Cronbach's alpha value of 0.77. If they want to measure misconceptions on some specific traits, such as causes of TBI, types of TBI, effects of TBI, treatment of TBI, things to do or not to do after TBI, and the susceptibility to a second blow after TBI, they may choose the 21 items with positive tendency of factor 1 (Table 12) (Cronbach's alpha=0.72). If they want to measure the misconceptions on the traits of the recovery process and coma they may choose the 11 items with positive tendency of factor 2 (Table 12) (Cronbach's alpha=0.71).

Suggestions for Future Research

Any future study may consider the re-examination of the items of the TBIKT to improve the reliability, validity, and generalizability of the assessment. To these ends, future studies may consider using the test pre-post and evaluating whether or not item functioning changes across time and also may consider having a larger sample size of premedical students. Moreover, the TBIKT may also be given to undergraduate health students, undergraduate physiotherapy students, medical students, and medical professionals to quantify how much the health and medical school curriculum is successful in addressing and removing the misconceptions about TBI effectively. The 9 items of TBIKT with the negative tendency of factor 1 and factor 2 (Table 12) (Cronbach's alpha=0.36) may go for further content validation to improve the reliability and can be added either with the TBIKT or with any qualitative TBI assessment. In addition, a semi-structured interviewing process can be added to this research to understand why students are confident on some ideas but not confident on others. The TBIKT and the open-ended assessment may work as the basis for semi-structured interview questions, where the interviewer should ensure a fair degree of freedom for the

participants to talk about their answer to an extent they would like. The literature review section which has collected information of different areas of interest and relevance should be covered by the interview (Werlang & Botega, 2003). A group of students can be purposefully selected for interviewing who did well in answering the open-ended questions and another group who showed a significant level of misconceptions about TBI in their open-ended responses and on the TBIKT. A comparison between these two groups may provide an interesting compliment to the findings in this study by identifying difference between the levels of misconceptions and to explore reasons why students have particular misconceptions.

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APPENDIX A

Cover and Permission Letter

Assessment of Premedical Student's Misconceptions on Traumatic Brain Injury

Date 11.20.2015

Dear participant student,

I am Md Hasan Iqbal inviting you to participate in a research study by completing a multiple choice assessment- traumatic brain injury knowledge test (TBIKT) about identifying pre-medical students misconceptions about traumatic brain injury. The TBITK is attached with this consent form. There are no known risks for your participation in this research study. The responses will only be examined by the researcher of this study and will ensure the confidentiality. The information collected may not benefit you directly. The information learned in this study may be helpful to educators, doctors and researchers. The information you provide will be used for research purpose. Your completed survey will be stored in password protected computers of 221, Science and Education Research Lab, Biological Sciences Building 1, WSU. The survey will take approximately 60 minutes to complete.

Individuals from the Department of Biological Sciences, the Institutional Review Board (IRB), Office of Research and Sponsored Programs and other regulatory agencies may inspect these records. In all other respects, however, the data will be held in confidence

to the extent permitted by law. Should the data be published, your identity will not be disclosed.

Taking part in this study is voluntary. You do not have to answer any questions that make you uncomfortable. You may choose not to take part at all. If you decide to be in this study you may stop taking part at any time. If you decide not to be in this study or if you stop taking part at any time, you will not lose any benefits for which you may qualify.

If you have any questions, concerns, or complaints about the research study, please contact: Md Hasan Iqbal, iqbal.4@wright.edu. If you have any questions about your rights as a research subject, you may call the Wright State IRB Office at (937) 775-4462. You can discuss any questions about your rights as a research subject with a member of the IRB or staff. The IRB is an independent committee made up of people from the University community, staff of the institutions, as well as people from the community not connected with these institutions. The IRB has reviewed this research study.

Sincerely,
MD HASAN IQBAL
Is this okay if we use your responses in our study? Your identity and responses will keep confidential.

- I agree to participate in this study
- I do not wish to participate in this study

TBIKT Assessment

PKS 1: Traumatic brain injury is an alteration in brain function due to an external mechanical force.

PKS 2: Typical Causes of TBI: Falls, firearms, motor vehicle accident, sports injury.

Q 1. Which of the following is NOT a potential cause of traumatic brain injury (TBI)?

a. Sustaining a blow to the head.
b. A gunshot to the head.
c. Exposure to loud sounds. (Data of 1st Open-Ended Question (OEQ), 27th response)
d. Whiplash. (14th OEQ, 21st response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 2. A person suffering from amnesia for a long period of time due to a car accident is likely suffering from-

a. Acquired brain injury (ABI). (4th PKS)
b. Severe TBI. (Faul et al., 2010)
c. Mild TBI. (Faul et al., 2010)
d. Post Traumatic Stress Disorder (PTSD). (4th OEQ, 16th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 3. A blow, bump or anything penetrating into the head may cause TBI. (Faul et al., 2010)
a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing

- Uncertain
- Confident
- Very confident

PKS 4: Typical causes of ABI: stroke, substance abuse, near drowning, infectious disease, seizure disorders, tumor, electric shock, toxic exposure, lightning strike, oxygen deprivation.

Q 4. Stroke can cause TBI. (1^{st} OEQ, 30^{th} Response)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 5. Which statement is true about the effects of TBI on brain function?

a. Only severe TBI disrupts the regular functions of the brain.
b. Mild TBI disrupts the regular function of the brain vastly.
c. The effects of TBI on the brain do not prevail for long period of time. (27^{th} PKS)
d. TBI always disrupts the regular functions of the brain. (Faul et al., 2010)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 6. Which statement about the recovery process of TBI is true?

a. The recovery process of any TBI is lengthy. (Ernst et al., 2009)
b. The recovery process of mild TBI is fast.
c. The more rest, the faster the recovery process will be. (26^{th} PKS)
d. During the recovery process, a person can complete all normal daily activities. (10^{th} PKS)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 27: Individual with severe brain injury can never be completely cured even though he/she tries hard.

Q 7. Which statement about the recovery process of severe TBI is true?

a. New neurons can bypass damaged neurons for complete recovery.(18th OEQ, 2nd response)
b. Young people can heal faster; complete recovery is possible for them. (17th OEQ, 12th response)
c. An individual with severe TBI may often gain complete recovery by working diligently toward recovery. (27th PKS)
d. An individual with severe TBI never completely recovers. (27th PKS)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 8. What social problems are people with TBI likely to encounter?

a. They often have to be institutionalized.
b. They are likely having difficulty in reintegrating into the society. (Willer et al., 1993)
c. They are likely to continue with normal social activities after recovery without facing any potential problems. (10th PKS)
d. Their social/emotional state should not be a problem as long as they are physically recovered. (25th PKS)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 5: Physical symptoms of TBI: problems in vision, hearing, speech, and motor coordination; headaches, dizziness, nausea, change of taste and smell, trouble controlling bladder, paralysis.

Q 9. Which of the following is a common physical symptom of TBI?

a. Lack of appetite. (https://www.nlm.nih.gov/medlineplus/ency/article/003121.htm)
b. Back pain. (http://www.webmd.com/back-pain/history-and-physical-exam-for-low-back-pain)
c. Trouble controlling bladder. (5th PKS)
d. Problems in planning. (6th PKS- cognitive symptom)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 6: Cognitive symptoms of TBI: trouble concentrating, lose items, short term memory deficits, forget about own identity, forget known people, slowness of thinking, impaired communication skills, problems in writing, spelling, planning, and judgment.

Q 10. Which of the following is a common cognitive symptom of TBI?

a. Problems in making decisions. (6th PKS)
b. Problems in vision, hearing, and speech. (5th PKS- physical symptom)
c. Problems in motor coordination. (5th PKS- physical symptom)
d. Depression (7th PKS- emotional symptom)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 7: Emotional symptoms of TBI: Easily annoyed, rapid mood swings, self-centeredness, anxiety, depression, restlessness, fatigue, and nightmares.

Q 11. Which is/are common emotional symptom(s) associated with TBI?
(5th and 7th PKS)

a. Impaired communication skills. (6th PKS- cognitive symptom)
b. Forgetting known people. (6th PKS- cognitive symptom)
c. Slow thinking. (6th PKS- cognitive symptom)
d. Nightmares. (7th PKS)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 8: If one suspects a head injury, first he/she needs to go to a physician for confirmation.

Q 12. If one suspects a head injury, what is the most important action that should be taken to confirm a brain injury?

a. Respond to questions one should know the answer to like name, date of birth etc. (5th OEQ, 3rd response)
b. Look at how they move their hands. (5th OEQ, 3rd response)
c. Go to a physician. (8th PKS)
d. Check the pupils for proper reaction. (5th OEQ, 21th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 9: Person with head injury needs to take lots of rest. He/she should not come back to daily activities without the permission of physician.

Q 13. What is the most important thing a person with a brain injury should do before returning to normal daily activity?

a. Get plenty of rest and not return to daily activities without clearance. (9th PKS)
b. Take proper medications for complete restoration of the brain. (6th OEQ, 19th response)
c. Test the functioning of the senses. (6th OEQ, 21th response)
d. Attend physical therapy in order to regain physical ability. (6th OEQ, 6th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 10: Since people with one head injury are prone to have another, person with a TBI should avoid doing anything that could cause another blow to the head

Q 14. David and Ryan are friends and they have to drive each day to go to school. David had a TBI one year ago due to a car accident, and recently began driving again. Between the two friends, who has more of a possibility to have a brain injury in the future?

a. Equally as likely
b. David
c. Ryan
d. This cannot be determined.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 22: Damage to a little part of the brain may cause significant harm.

Q 15. A person with a TBI to a small part of the brain can likely return to his/her normal daily activities quickly.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 16. Which statement is true about the severity of a brain injury to a small part of the brain?

a. Damage to a small part of the brain is not a big issue; it will likely recover quickly. (22nd PKS)
b. Damage to a small part of the brain may cause significant harm depending on the place. (22nd PKS)
c. Brain injuries are always severe. It does not matter which part of the brain is affected or how much. (Faul et al., 2010; A TBI may be "mild" or "severe" based on severity of the patient's mental status.)
d. The brain is capable of fast rerouting to recover from small injuries. (15th OEQ, 16th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 11: A brain injured person should talk with doctor when it's safe to drive a car because he/she may lose the ability to react quickly after head injury.

Q 17. When should a person with TBI start driving again?

a. As soon as he/she feels good, he/she can start driving.
b. The person needs to get clearance before starting driving. (11th PKS)
c. He/she can drive, unless he/she drinks alcohol or takes drugs before driving.
d. Driving is prohibited after any TBI.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 12: Person with TBI should take only the medications approved by doctor, and should not drink alcohol without the permission of doctor.

Q 18. Drinking alcohol does not have any effect on the recovery process from TBI. (12th PKS)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 16: An individual with an injury to the head can wake up from an unconscious condition with a greater possibility to have lasting effects on brain.

Q 19. Which statement is FALSE about a man who has gone into a coma due to a blow to the head?

a. Lost consciousness is an indication of severe TBI. (Faul et al., 2010: Patients with amnesia for a long post-injury period are likely suffering from severe TBI.)
b. It is likely he may wake up from the coma without any lasting effects. (16th PKS)
c. He may lose some previous memory after waking up from the coma. (6th PKS)
d. He may lose cognitive ability after waking up from the coma. (6th PKS)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 20. Most individuals can wake up from a coma lasting several weeks without having problems in recognizing and speaking to others. (Ernst et al., 2009)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing

- Uncertain
- Confident
- Very confident

PKS 15: A brain injured person is not concerned about what is going on his/her surroundings when in a coma.

Q 21. Which statement is true about a man or woman who is in a coma due to TBI?

a. He/she is not aware of what is going on in his/her surroundings. (15th PKS)
b. The coma heals the injury. As soon as he/she wakes up from the coma he/she should not have severe effects on the brain.
c. It is likely he/she will not survive, since a coma is a severe state.
d. Since the brain is awake in a coma, he/she has awareness his/her surroundings. (11th OEQ, 6th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 22. People with TBI can recall things that happened during a coma. (11th OEQ, 21th response)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 17: A second blow to the head does not help the person to bring back forgotten memory.

Q 23. A second blow to the head can help a person bring back forgotten memory. (17th PKS)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 18: An individual with TBI usually finds it more difficult to remember the events after a brain injury than before.

Q 24. Which memories are more difficult to remember for a person with TBI?

e. Events following the brain injury. (18^{th} PKS)
f. Events preceding the brain injury.
g. Events before and after the brain injury.
h. TBI can improve recollection of long term memories. (13^{th} OEQ, 25^{th} response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 20: Whiplash injuries are severe because they can cause significant damage to the brain even without any direct blow to the head.

Q 25. Which statement may be true if John has sustained a whiplash injury (a neck injury that can occur when the head suddenly moves backward and then forward) without any direct blow to the head in a car accident?

a. Since there is not a direct blow to the head, his brain will likely not be damaged. (14^{th} OEQ, 21^{st} response)
b. His brain may have been damaged significantly even without any direct blow to the head. (20^{th} PKS)
c. It may cause minor injury to the brain but it will likely not be significant. (14^{th} OEQ, 22^{st} response)
d. Only the neck and spinal cord will be affected by whiplash. (14^{th} OEQ, 26^{th} response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 21: Most people are not concerned about how their attitude could be influenced by brain damage.

Q 26. Rapid mood swings are emotional symptoms of TBI. Do you think most TBI patients are concerned about how their attitude or mood could be influenced by brain damage?

a. Yes, most people with TBI are concerned.
b. No, most people with TBI are not concerned. (21^{st} PKS)

Explain your answer.
How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 23: An individual with one brain injury is prone to have another.

Q 27. Adam, a football player, had a TBI 2 months ago. He started doing all his normal daily activities except for playing football. What do you think about his chance of having another brain injury?

a. He is not at risk of sustaining another TBI as long as he is not playing football. (7^{th} OEQ, 14^{th} response)
b. He is more prone to have another TBI than before his brain injury even though he is not playing football. (23^{rd} PKS)
c. His risk of sustaining another TBI is lessened because the skull becomes stronger after it heals from an impact. (16^{th} OEQ, 22^{nd} response)
d. His risk of sustaining another TBI is no greater or worse than the average person. (7^{th} OEQ, 1^{st} response)

How confident are you in your answer?

- Guessing
- Uncertain

- Confident
- Very confident

PKS 24: People with one head injury have less ability to withstand a second blow.

Q 28. Adam, a football player, had a TBI 2 months ago. Now he has sustained a second blow to his head. What do you think about his ability to withstand the second blow?

a. Due to his prior TBI, he has more ability to withstand the second blow. (24th PKS)
b. Due to his prior TBI, he has less ability to withstand the second blow. (24th PKS)
c. His prior TBI has no effect on his ability to withstand a second blow. (24th PKS)
d. Withstanding the second blow is only dependent upon the severity of that blow to the head. (Suggested by a reviewer)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 25: If a survivor feels good after treatment that does not means he/she is completely cured.

Q 29. If a TBI survivor feels good after treatment, that means he/she is completely cured. (25th PKS)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 26: When a person with TBI is in the recovery process, he/she may needs to take some exercise and does not necessarily need to take rest all time.

Q 30. When a person with TBI is in the recovery process-

e. The person needs to do physical exercise and take moderate rest. (26th PKS)

f. He/she needs to take rest all of the time. Even a little physical exercise may be harmful at this stage. (26th PKS; 17th OEQ, 4th response)
g. The person needs to do a large amount of physical exercise.
h. Most patients should complete 30 minutes of exercise and get 8-10 hours of sleep each day. (17th OEQ, 4th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 27: Individual with severe brain injury can never be completely cured even though he/she tries hard

Q 31. Jessica, a 10 year old girl, had a severe brain injury one year ago. Which of the statements below about her recovery is true?

e. She can be completely cured if she puts in enough effort. (18th OEQ, 4th response)
f. Young people can heal faster; she will likely be completely cured within 1-2 years. (18th OEQ, 12th response)
g. She will likely never be completely cured. (27th PKS)
h. She can be completely cured if enough neurons are recruited to take over the loss of the damaged ones. (18th OEQ, 2nd response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

PKS 28: Since undeveloped areas of brain mature from previously damaged portions and it is difficult to predict the later development, younger brains are comparatively more vulnerable than the matured brains.

Q 32. Which statement is correct about younger brains?

a. Adults' brains are comparatively more vulnerable to brain injury than younger brains. 19th OEQ, 10th response)

b. Younger brains are comparatively more vulnerable to brain injury than adults' brains. (28th PKS)
c. The brain is larger in younger people. (19th OEQ, 11th response)
d. Younger brains heal faster than adults' brains. (18th OEQ, 12th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 33. People with amnesia due to TBI-

a. Can learn simple things, but not difficult things with high cognitive demand.
b. Usually do not have trouble learning new things, only remembering what they learned.
c. Usually have trouble learning new things. (Ernst et al., 2009)
d. Are incapable of learning new cognitive skills.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 34. Complete recovery from TBI is not possible. (Ernst et al., 2009)

A. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 35. Which one is NOT good advice for a brain injured person who is in the recovery process?

a. To take rest and get some physical exercise according to the doctor's advice. (26th PKS)
b. To take rest and remain inactive during recovery from a brain injury. (Ernst et al., 2009)
c. To engage in cognitive exercises. (17th OEQ, 20th response)
d. Avoid rigorous physical activity. (17th OEQ, 20th response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 36. A head injury can cause brain damage even if the person is NOT knocked out. (Guilmette & Paglia, 2002)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 37. After a TBI, people most often experience-

a. Depressed, sad, and hopeless mood. (Pappadis et al., 2011)
b. More confidence about withstanding a second blow. (24th PKS)
c. No major change in personality. (7th PKS, 3rd OEQ, 5th response)
d. Extreme happiness. (4th OEQ, 3rd response)

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 38. Which statement is correct about recovery from most brain injuries?

a. Recovery should typically be completed in six months to one year.
b. Recovery from injury is usually complete within a year.
c. Recovery may continue many years after the injury. (Pappadis et al., 2011)
d. It is impossible to quantify the exact amount of time needed for recovery, but given enough time, the person's brain should heal completely.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 39. Genetic disorders are a cause of TBI. (Data of OEQ 1, response 30 "genetic disorder that affects the brain")

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 40. A person with TBI may lose some physical and cognitive skills and need the help of others to re-learn those skills. (14^{th} PKS)

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

41. Where did you get information about TBI in the past? Check all that apply.

I read about TBI in papers.
I read about TBI in magazines.
I saw programs about TBI on TV.
I saw movies/drama about TBI.
I have talked to friends about TBI.
I have talked to my family about TBI.
I have talked to professionals about TBI.
I had TBI.
I have a close family member with TBI.
I have a friend with TBI.
Others

APPENDIX B

Revised TBIKT

Q 1. Which of the following is NOT a potential cause of traumatic brain injury (TBI)?

e. Sustaining a blow to the head.
f. A gunshot to the head.
g. Exposure to loud sounds.
h. Whiplash.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 2. A person suffering from amnesia for a long period of time due to a car accident is likely suffering from-

a. Acquired brain injury (ABI).
b. Severe TBI.
c. Mild TBI.
d. Post Traumatic Stress Disorder (PTSD).

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 3. A blow, bump or anything penetrating into the head may cause TBI.
a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 4. Stroke can cause TBI.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 5. Which statement is true about the effects of TBI on brain function?

a. Only severe TBI disrupts the regular functions of the brain.
b. Mild TBI disrupts the regular function of the brain vastly.
c. The effects of TBI on the brain do not prevail for long period of time.
d. TBI always disrupts the regular functions of the brain.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 6. Which statement about the recovery process of TBI is true?

a. The recovery process of any TBI is lengthy.
b. The recovery process of mild TBI is fast.
c. The more rest, the faster the recovery process will be.
d. During the recovery process, a person can complete all normal daily activities.

How confident are you in your answer?

- Guessing

- Uncertain
- Confident
- Very confident

Q 7. Which statement about the recovery process of severe TBI is true?

a. New neurons can bypass damaged neurons for complete recovery'
b. Young people can heal faster; complete recovery is possible for them.
c. An individual with severe TBI may often gain complete recovery by working diligently toward recovery.
d. An individual with severe TBI never completely recovers.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 8. What social problems are people with TBI likely to encounter?

a. They often have to be institutionalized.
b. They are likely having difficulty in reintegrating into the society.
c. They are likely to continue with normal social activities after recovery without facing any potential problems.
d. Their social/emotional state should not be a problem as long as they are physically recovered.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 9. Which of the following is a common cognitive symptom of TBI?

a. Problems in making decisions.
b. Problems in vision, hearing, and speech.
c. Problems in motor coordination.
d. Depression

How confident are you in your answer?

- Guessing

- Uncertain
- Confident
- Very confident

Q 10. If one suspects a head injury, what is the most important action that should be taken to confirm a brain injury?

a. Respond to questions one should know the answer to like name, date of birth etc.
b. Look at how they move their hands.
c. Go to a physician.
d. Check the pupils for proper reaction.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 11. What is the most important thing a person with a brain injury should do before returning to normal daily activity?

a. Get plenty of rest and not return to daily activities without clearance.
b. Take proper medications for complete restoration of the brain.
c. Test the functioning of the senses.
d. Attend physical therapy in order to regain physical ability.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 12. David and Ryan are friends and they have to drive each day to go to school. David had a TBI one year ago due to a car accident, and recently began driving again. Between the two friends, who has more of a possibility to have a brain injury in the future?

e. Equally as likely
f. David
g. Ryan
h. This cannot be determined.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 13. A person with a TBI to a small part of the brain can likely return to his/her normal daily activities quickly.

a. True b. False

Explain your answer.

Q 14. When should a person with TBI start driving again?

a. As soon as he/she feels good, he/she can start driving.
b. The person needs to get clearance before starting driving.
c. He/she can drive, unless he/she drinks alcohol or takes drugs before driving.
d. Driving is prohibited after any TBI.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 15. Drinking alcohol does not have any effect on the recovery process from TBI.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 16. Which statement is FALSE about a man who has gone into a coma due to a blow to the head?

a. Lost consciousness is an indication of severe TBI.

b. It is likely he may wake up from the coma without any lasting effects.
c. He may lose some previous memory after waking up from the coma.
d. He may lose cognitive ability after waking up from the coma.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 17. Most individuals can wake up from a coma lasting several weeks without having problems in recognizing and speaking to others.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 18. Which statement is true about a man or woman who is in a coma due to TBI?

a. He/she is not aware of what is going on in his/her surroundings.
b. The coma heals the injury. As soon as he/she wakes up from the coma he/she should not have severe effects on the brain.
c. It is likely he/she will not survive, since a coma is a severe state.
d. Since the brain is awake in a coma, he/she has awareness his/her surroundings.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 19. People with TBI can recall things that happened during a coma.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 20. Which memories are more difficult to remember for a person with TBI?

a. Events following the brain injury.
b. Events preceding the brain injury.
c. Events before and after the brain injury.
d. TBI can improve recollection of long term memories.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 21. Which statement may be true if John has sustained a whiplash injury (a neck injury that can occur when the head suddenly moves backward and then forward) without any direct blow to the head in a car accident?

a. Since there is not a direct blow to the head, his brain will likely not be damaged.
b. His brain may have been damaged significantly even without any direct blow to the head.
c. It may cause minor injury to the brain but it will likely not be significant.
d. Only the neck and spinal cord will be affected by whiplash.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 22. Rapid mood swings are emotional symptoms of TBI. Do you think most TBI patients are concerned about how their attitude or mood could be influenced by brain damage?

c. Yes, most people with TBI are concerned.

d. No, most people with TBI are not concerned. (21st PKS)

Explain your answer.
How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 23. Adam, a football player, had a TBI 2 months ago. He started doing all his normal daily activities except for playing football. What do you think about his chance of having another brain injury?

a. He is not at risk of sustaining another TBI as long as he is not playing football.
b. He is more prone to have another TBI than before his brain injury even though he is not playing football.
c. His risk of sustaining another TBI is lessened because the skull becomes stronger after it heals from an impact.
d. His risk of sustaining another TBI is no greater or worse than the average person.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 24. Adam, a football player, had a TBI 2 months ago. Now he has sustained a second blow to his head. What do you think about his ability to withstand the second blow?

a. Due to his prior TBI, he has more ability to withstand the second blow.
b. Due to his prior TBI, he has less ability to withstand the second blow.
c. His prior TBI has no effect on his ability to withstand a second blow.
d. Withstanding the second blow is only dependent upon the severity of that blow to the head.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 25. If a TBI survivor feels good after treatment, that means he/she is completely cured.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 26. Jessica, a 10 year old girl, had a severe brain injury one year ago. Which of the statements below about her recovery is true?

a. She can be completely cured if she puts in enough effort.
b. Young people can heal faster; she will likely be completely cured within 1-2 years.
c. She will likely never be completely cured.
d. She can be completely cured if enough neurons are recruited to take over the loss of the damaged ones.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 27. Which statement is correct about younger brains?

a. Adults' brains are comparatively more vulnerable to brain injury than younger brains.
b. Younger brains are comparatively more vulnerable to brain injury than adults' brains.
c. The brain is larger in younger people.
d. Younger brains heal faster than adults' brains.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 28. Complete recovery from TBI is not possible.

A. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 29. Which one is NOT good advice for a brain injured person who is in the recovery process?

a. To take rest and get some physical exercise according to the doctor's advice.
b. To take rest and remain inactive during recovery from a brain injury.
c. To engage in cognitive exercises.
d. Avoid rigorous physical activity.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 30. A head injury can cause brain damage even if the person is NOT knocked out.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 31. After a TBI, people most often experience-

a. Depressed, sad, and hopeless mood.
b. More confidence about withstanding a second blow.
c. No major change in personality.
d. Extreme happiness.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 32. Which statement is correct about recovery from most brain injuries?

a. Recovery should typically be completed in six months to one year.
b. Recovery from injury is usually complete within a year.
c. Recovery may continue many years after the injury.
d. It is impossible to quantify the exact amount of time needed for recovery, but given enough time, the person's brain should heal completely.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 33. A person with TBI may lose some physical and cognitive skills and need the help of others to re-learn those skills.

a. True b. False

Explain your answer.

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

Q 34. Nightmare is an emotional symptom of TBI?

a. True b. False

How confident are you in your answer?

- Guessing
- Uncertain
- Confident
- Very confident

APPENDIX C

Open-Ended Questions

1. List and explain multiple ways that a person may acquire a brain injury.
2. What kind of physical problems are commonly associated with traumatic brain injury?
3. What kind of cognitive problems are commonly associated with traumatic brain injury?
4. What kind of emotional problems are commonly associated with traumatic brain injury?
5. If one suspects a head injury, what action should he/she take to confirm whether or not a brain injury has occurred?
6. What action does a person with brain injury need to take before returning to normal daily activities?
7. Do you think a person with traumatic brain injury has a higher chance to have another brain injury than a person without a previous TBI? Explain.
8. What kind of things a person with traumatic brain injury should NOT DO without the permission of doctor? Why you think so? Explain your reasoning.
9. If a person with a traumatic brain injury has memory problems, what action should he/she take to better remember things?

10. If a person experiencing traumatic brain injury has lost certain cognitive or motor skills, what action does that person need to take to re-learn some of these skills?
11. Define what a "coma" is. Do you think a person experiencing a coma is aware of his/her surroundings? Why or why not?
12. Do you think a second blow to the head helps the person to bring back forgotten memory? Why or why not?
13. Describe the effect you think a traumatic brain injury has on a person's memory. To what extent do you think traumatic brain injury affects memory?
14. Do you think whiplash injury (neck injury that can occur when the head suddenly moves backward and then forward) can cause damage to the brain? Explain you answer.
15. Do you think damage to a little part of the brain may be harmful for a person? Why or why not?
16. Do you think one head injury decreases one's ability to withstand a second blow? Why or why not?
17. Describe the roles of rest and exercise in recovery from traumatic brain injury. Do you think there is an ideal amount of rest and exercise to facilitate recovery? Why or why not?
18. Do you think a traumatic brain injury can be cured completely? Why or why not?
19. Why is it that the brains of younger individuals are more vulnerable to traumatic injury than the brains of adults?
20. Why an individual with injury to head wake up from coma with a greater possibility to have lasting effects on brain?

Data from Open-Ended Responses

Table16.

Open-ended question number 12. Do you think a second blow to the head would help the person to bring back forgotten memory? Why or why not?

PKS 17. "a second blow to the head does not help the person to bring back forgotten memory".

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct conceptions		
New damage	31	"I do not think that a second blow would help the person recall forgotten memories. If anything this would only cause more damage to the brain and the mental health of the individual". (36th response)
Memory can be regained	1	"A memory can be regained from neuro-regeneration, growth factors, and working with specialists". (20th response)
Hemorrhaging	1	"Another blow may cause more hemorrhaging and brain damage and actually cause the onset of more symptoms". (22nd response)
Impact on mental health	1	"A second blow may only cause more damage to the brain and to the mental health of the individual". (36th response)
Misconceptions		
Second blow bring back forgotten memory	6	"This would be due to the second blow affecting the brain in a way where the storage place of these lost memories reconnects to the brain as a whole, allowing access to the memories that were otherwise inaccessible". (15th response)
Second blow wipe out recent memories	2	"It might just wipe memories that were fairly recent".

Table 17.

Open-Ended Question number 15. Do you think damage to a little part of the brain may be harmful for a person? Why or why not?

PKS 22. "damage to a little part of the brain may cause significant harm".

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct Conceptions		

Little organs are important	17	"There could be small areas of the brain that are incredibly vital that if damaged, could produce more noticeable side effects". (4th response)
Depends on which part	23	"It depends on which area of the brain is injured. If some places are injured, the brain can compensate in another area. But some areas have vital functions and injury to them would cause serious harm". (7th response)
Any damage is harmful	3	"Any damage to the brain is harmful. Every part of the brain is important for various tasks and some of these tasks are more pivotal than others but I believe that any harm to the brain could affect the persons' life in some way". (33rd response)
Recoveries from minor injuries easier	2	"Some injuries to small parts of the brain may not cause any harm and recovery is easier". (36th response)
Brain connected to itself via neurons	1	"The brain is such a vital organ and is all connected to itself through neurons. Therefore, if one small area of the brain is damaged, the entire brain can potentially suffer as a result of these connecting neurons". (18th response)
Different parts have different functions	1	"Every parts of the brain have functions solely unique to it". (19th response)
Misconceptions		
Some injuries to small parts of the brain cause no harm	2	"Some injuries to small parts of the brain may not cause any harm". (36th response)
Recovery from little portion easier	1	"If damage is to a little portion, recovery could be easier and faster." (35th response)
Brain capable of fast rerouting	1	"The brain is capable of fantastic rerouting because of the high order of synaptic connections". (16th response)

Table18.

Open-ended question number 18. Do you think a traumatic brain injury can be cured completely? Why or why not?

PKS 27. "Individual with severe brain injury can never be completely cured even though he/she tries hard".

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct conception		

Complete regeneration is not possible	17	"Once someone has a traumatic brain injury something must have been damaged and would not be able to regenerate itself". (1st response)
Brain is delicate	5	"Brain is very delicate and when events like injury occur in the brain it take time to cure and in many cases, the cure is not 100%". (19th response)
Can get recovery close to normal	4	"Through rehabilitation, someone who has suffered a traumatic brain injury can get close to normal again but they will have lasting effects for the rest of their lives". (8th response)
Misconceptions		
Complete cure possible	7	"I think that over time with the right therapy, a TBI could be cured nearly 100%". (33rd response)
Complete cure depends on severity and injured part of brain	4	"I'm sure some brain injuries can be cured completely, while others cannot. I think it just depends on the nature of the injury and the area/region of the brain that it affects". (31st response)
Less severe brain injury can be completely cured	1	"I believe that some brain injuries probably can while others cannot. I think it just depends on the severity of the injury". (23rd response)
If enough neurons are recruited	1	"Complete cure possible, if enough neurons are recruited to take over the loss of the damaged ones". (2nd response)
Neurologist can rewire connection	1	"Some damage can be more easily overcome by neurologican rewiring within the connections/synapses in the brain". (25th response)

Table19.

Open-ended question number 19. Why is it that the brains of younger individuals are more vulnerable to traumatic injury than the brains of adults?

PKS 28. "Since undeveloped areas of brain mature from previously damaged portions and it is difficult to predict the later development, younger brains are comparatively more vulnerable than the matured brains".

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct Conceptions		
Still developing	19	"Younger brains are also still developing making them more vulnerable to traumatic injury". (32nd response)
Less developed	8	"Brains of young individuals are lesser developed than those of adults, resulting in higher ability to become injured". (15th response)

Skull is stronger in adult	6	"Adult brains are protected by adult skulls, which have fully formed and are harder than the still-forming, softer skulls of young individuals". (15th response)
More active	6	"Younger people tend to be more active, placing themselves in situations where a TBI can occur". (9th response)
Injury can Impact future development	5	"When younger individuals suffer from a brain injury, the injury can impact the future development of their brain and result in further cognitive impairment'. (14th response)
Misconceptions		
Adults' brains more vulnerable	2	"Adults' brains were more vulnerable, since their brains have already finished forming connections." (10th response)
Brain larger in younger people	1	"Brain is larger in younger individuals and therefore when an injury occurs, the brain is subject to more pressure due to inability of the brain to expand outside of the skull". (11th response)

Table20.

Open-ended question number 20. Why would an individual wake up from a coma who had brain injury with a greater possibility to have lasting effects on the brain?

PKS 16. "An individual with injury to head wake up from the unconscious condition with a greater possibility to have lasting effects on brain".

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct Conceptions		
Coma indicates high level of damage	10	"The coma could be a sign that the original TBI was extremely significant and stressful on the brain". (29th response)
Brain is not being utilized in coma, so it loses function	6	"The inactivity of the brain in the coma may lead to difficulty regaining the function". (24th response)
Coma takes away from treatment/healing	5	"Individual just recovered from coma may have long lasting effects because of the brain injury lingering during the coma without being effectively treated or healed." (5th response)
Waking up from coma too early overworks the brain, reducing recovery	4	"By waking from the coma, it could be possible that the brain has not rested well enough and that by being awake causes the possibility of more permanent effects". (32nd response)
Lack of oxygen induced by coma	2	"During the coma the individual could have suffered lack of oxygen to the brain causing brain cells to die". (36th response)

Lack of stimulation while in coma	1	"This lack of stimulation could contribute to the brain not recovering as quickly". (8th response)
Misconceptions		
Miracles cause person to wake up from coma	1	"It is often unknown how or why people wake up from a coma when professionals all agree that they won't. I guess I attribute it to miracles at that point". (37th response)

Table21.

Open-ended question number 3. What kind of cognitive problems are commonly associated with traumatic brain injury?

PKS 6. Cognitive symptoms of TBI: trouble concentrating, lose items, short term memory deficits, forget about own identity, forget known people, slowness of thinking, impaired communication skills, problems in writing, spelling, planning, and judgment.

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct Conceptions		
Memory loss	24	"In many cases traumatic brain injuries can cause individuals to lose long term memory, short term memory and the ability to create new memories". (17th response)
Forgetfulness	5	"They may be confused or feel 'mentally foggy', they may be unable to recognize objects- even some ordinary, daily ones that they used before the injury". (4th response)
Impaired concentration skill	11	"Cognitive problems may include a difficulty with focusing therefore a hindered ability to solving problems. It may also cause a slower grasp of concepts". (21st response)
Writing and spelling problem	10	Impaired "reading, writing, and verbal skills". (20th response)
Impaired logical reasoning	6	"Evaluation of situations, judgment and reasoning of different things that go on in a normal life are very common in brain injuries". (27th response)
Difficulty in solving problem	5	"Cognitive problems may include a difficulty with focusing therefore a hindered ability to solving problems". (21st response)
Impaired judgment	3	"Cognitive problems commonly associated with traumatic brain injury are memory loss/impairment, loss of emotional stability, and judgment impairment". (9th response)
Problem in decision making	2	"Difficulty thinking clearly and making decisions". (24th response)
Impaired communication skill	1	"Memory loss, communication problems" (13th response)

Misconceptions		
Confusion of cognitive with physical problems	14	"Motor skills" (13th response), "sensory impairment" (8th , 11th, 16th, 22nd , and 29th responses), "speech" (3rd, 4th, 8th, and 22nd responses), "mood swing" (18th and 20th responses)

Table22.

Open-ended question number 11. Define what a "coma" is. Do you think a person experiencing a coma is aware of his/her surroundings? Why or why not?

PKS 15. "A brain injured person does not concern about what is going on his/her surroundings when in coma".

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct Conceptions		
Not aware	15	"A coma is when a person is an unconscious state of mind. I do not think a person in a coma is aware of their surroundings because they are unconscious". (23rd response)
Deep sleep	7	"I do not think a person is aware of their surroundings during a coma because I think it is like a deep sleep where they might have dreams but cannot wake up or their brain won't let them wake up". (1st response)
Higher level brain function ceases	3	"A person in a coma would not be aware of their surroundings, as higher level brain function most likely ceases, leaving only those functions required to sustain life". (9th response)
Active metabolic state	2	"A coma is a depressed sleep state in which the person is not aware of their surroundings due to their minimal neural activity but still has metabolic and respiratory processes still operating such that the person is able to live off of live-support". (5th response)
Misconceptions		
Awareness in coma	17	"I am not actually sure. All I know is what I have seen in movies and it seems that sometime the person has an idea of what is going on but the body has no idea how to communicate it". (3rd response)
Different levels of coma	3	"I think that there are different levels of comas, some people are in deeper levels of a coma and have no awareness of their surroundings, while others understand what is going on around them and are in more of a stupor". (7th response)

Table23.

Open-ended question number 4. What kind of emotional problems are commonly associated with traumatic brain injury?

PKS 7. "Emotional symptoms of TBI: Easily annoyed, rapid mood swings, self-centeredness, anxiety, depression, restlessness, fatigue, and nightmares".

Correct Conceptions/ Misconceptions	**Count**	**Example Quote**
Correct Conceptions		
Depression	26	"Depression is probably the most common emotional problem associated with TBI". (8th response)
Anger	12	"Emotional problems would include things such as anger" (9th response)
Rapid mood swings	11	"Mood swings are commonly associated with TBI. The mood swings tend to be similar to manic episodes. This can be due to injury to parts of the brain that control temper and rationale or to PTSD". (20th response)
anxiety	7	"I think emotional problems would include anxiety" (1st response)
Social isolation	4	"They lack the ability to socially process and act appropriately to a given situation". (25th response)
Misconceptions		
Confusion between physical, cognitive, and emotional symptoms	3	"Depending on the trauma: PTSD, memory, cognitive functions, speech, hearing and attention". (16th response)

Table24

Open –ended question number 17. Describe the roles of rest and exercise in recovery from traumatic brain injury. Do you think there is an ideal amount of rest and exercise to facilitate recovery? Why or why not?

PKS 25. "If a survivor feels good after treatment that does not means he/she is completely cured" and PKS 26. "When a person with TBI is in the recovery process, he/she may needs to take some exercise and does not necessarily need to take rest all the time.

Correct Conceptions/ Misconceptions	Count	Example Quote
Correct Conceptions		
Depends on severity	12	"I think it depends on the severity of the injury. If bleeding or bruising may have occurred, I would argue more for rest, then exercise once any remaining swelling and clotting is through". (29th response)
Rest most important, exercises follow	8	"I believe a balance between rest and exercise is necessary to recover from a traumatic event. Directly after the injury occurs rest should predominate and very little exercise. This relationship should be inversely proportional as time moves on". (28th response)
Avoid straining your brain	4	"I think that the most ideal conditions for recovery from a brain injury revolve around avoiding straining your brain more than you have to". (6th response)
Misconceptions		
Ideal amount of rest and exercise	2	"I don't know the roles, but I'm sure there is an ideal amount". (13th response)
Physical exercise dangerous	2	"Following a traumatic brain injury, it is essential to receive the same amount of sleep so that the brain can recover, and to exercise MENTALLY, physical exercise is more dangerous to the person". (4th response)

Table25.

Open-ended question number 13. Describe the effect you think a traumatic brain injury has on a person's memory. To what extent do you think traumatic brain injury affects memory?

PKS 18. "An individual with TBI usually finds it difficult to remember the memories after a brain injury than before".

Correct Conceptions/ Misconceptions	Count	Example Quote
Correct Conceptions		
TBI has effect on memory	34	"Traumatic brain injury has a great effect on a person's memory by potentially erasing memories and cognitive abilities that the person has developed over time to a degree that they may never recover those skills even with therapy". (5th response)
Depends on part of brain	14	"This depends on which sections of the brain are impacted by the brain injury. If the occipital lobe were injured, it is unlikely that problems with memory will

		result". (14th response)
Depends on severity	11	"A traumatic brain injury can affect a person's memory in a variety of ways. It is dependent on the severity of the injury but can hinder new memories from forming". (18th response)
Short and long term memory loss	7	"A traumatic brain injury has the potential to make a person suffer short or long-term memory loss. I think generally, people do not recall the trauma so I think it is safe to assert that all traumatic brain injury causes a form of short-term memory loss. However, circumstances can cause serious damage to the brain and, in effect, long-term memory loss". (20th response)
Misconceptions		
All brain injuries have some effect on memory	3	"I think that all brain injury does have some effect on memory, especially memory that was recorded around the time of the injury". (8th response)
TBI can lead to regaining of memories from childhood	2	"Traumatic brain injury can affect memory, both short and long term. A TBI could cause a person to lose short-term memory yet retain memories from childhood". (9th response)