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The Cost of Treating Posttraumatic Stress Disorder and Mild Traumatic Brain Injuries

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THE COST OF TREATING POST TRAUMATIC STRESS DISORDER AND MILD TRAUMATIC BRAIN INJURIES

THESIS

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Abstract

Mild Traumatic Brain Injuries (mTBIs) and Post Traumatic Stress Disorder (PTSD) are two of the signature wounds of war. Due to the advances in technology the survival rates are higher than in previous wars, however, the weaponry has changed. The world has seen an increase in the use of suicide bombs, improvised explosive devices (IEDs) and rocket propelled grenades (RPGs) which increases the number of blast related injuries. One of the major problems with blast related injuries is that they can be invisible to the naked eye. The lack of physical evidence suggests the soldier is not injured and can be sent back into battle, when there could be an undetected internal injury.

Due to the overlap in symptoms, many soldiers are being treated for PTSD instead of mTBI, which can cause long-term damage. In order to shed light on this issue, this thesis evaluates 2007-2008 active duty medical costs to determine the costs the PTSD and mTBI. The findings suggest that mTBI and PTSD account for .53% and 1.8%, respectively, of the 2008 population data sample. While this may seem like a small percentage this was only two months of data. However, it is important to properly diagnose mTBI and PTSD because these illnesses could cost the military member thousands of dollars in out of pocket medical costs.

This work is dedicated to my family. Without my family's love, support, and understanding I would never have been able to accomplish such an undertaking. I also dedicate my work to the soldiers fighting to keep us free. I hope my work will help ensure their medical needs are met.

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THE COST OF TREATING POST TRAUMATIC STRESS DISORDER
AND MILD TRAUMATIC BRAIN INJURIES

Chapter I: Introduction

Background

Posttraumatic Stress Disorder (PTSD) and Traumatic Brain Injuries (TBI) are the signature wounds of war for Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). “With advances in body armor technology and acute trauma care, many military service members are now surviving injuries that would have been fatal in previous wars” (Lew, Cifu, Sigford, Scott, Sayer, & Jaffee, 2007). The injuries sustained may be invisible to the naked eye, to other service members, family members, and society in general. Without recognition of the injuries the recovery can be prolonged and cause family problems, employment problems and even societal problems. Due to the increase in survival rates the Department of Defense (DoD) needed to provide proper medical care and in the August 2008 edition of the Air Force Times it was reported that the DoD would spend an “unprecedented $300 million this summer on research for post traumatic stress disorder and traumatic brain injury, offering hope not only for troops but hundreds of thousands of civilians” (Zoroya, 2008).

The cost of the Iraq and Afghanistan wars are continually increasing and to date the DoD has allocated $1.05 trillion since the time of inception (Cost of War). In December 2008, Ms. Linda Bilmes stated at the 133rd Annual Meeting of the American

Neurological Association that “long-term medical care and disability benefits to veterans is projected to cost about $700 billion. With the inclusion of medical expenses for veterans with neurologic and neuropsychiatric disorders, such as TBI and PTSD, the costs of long-term medical care are likely to surpass the operating costs of the war” (Jannicelli, 2008).

The recent conflicts have created problems for doctors due to the increased likelihood of exposure to high-energy explosions and blasts. Rocket-propelled grenades, improvised explosive devices, explosively formed projectiles and land mines create these explosions or blasts. Currently in Operation Enduring Freedom and Operation Iraqi Freedom (OEF/OIF), upward of 78% of combat injuries are the result of explosive munitions (Owens, Kragh, Wenke, Macaitis, Wade, & Holcomb, 2008). The equipment the services issue is protecting the soldiers enough to save their lives, but is leaving some of the soldiers with complex medical issues. The TBI definition proposed by the American Congress of Rehabilitation Medicine includes (1) associated diminished or altered state of or loss of consciousness (LOC); (2) posttraumatic amnesia for less than 24 hours, and (3) a Glasgow Coma Scale score of 13 or greater quantifying level of consciousness (Harrington, et al., 1993). PTSD as defined in the DSM-IV Text Revised, is an anxiety disorder that encompasses four major criteria: witnessing an event that is threatening to one’s well-being, symptoms of reexperiencing, avoidance of thoughts, and increased arousal. One word to describe the more complex type of illnesses military doctors are treating is polytrauma.

Polytrauma “encompasses injuries to more than one physical region or organ system, one of which may be life threatening, and which results in physical, cognitive, psychological, or psychosocial impairments and functional disability" (Belanger, Uomoto, & Vanderploeg, 2009). These types of injuries are referred to as "blast injuries" and are a frequent occurrence in Iraq and Afghanistan.

The major issue is that the comorbid symptoms lend themselves to misdiagnosis of mTBI with PTSD. For this reason, it is difficult to determine which diagnosis is correct, or whether both co-occur. In the case of mild symptoms, neither condition may be diagnosed. There are costs associated with all of these situations. Failing to treat a condition can lead to long-term increases in care as well as loss of function. Treating a condition that is not present is needlessly expensive and can directly conflict with a more appropriate treatment as, for example, if drugs given to relieve anxiety in PTSD aggravate an undiagnosed brain injury.

Currently there is no specific tool to determine if a soldier has mTBI or PTSD. Most of the tools used to diagnose soldiers are questionnaires, which used alone may lead to misdiagnosis. Some soldiers lie on these types of questionnaires in order to prevent delaying their journey home (Tanielian & Jaycox, 2008). There are also follow up questionnaires a few months after deployment that may help determine if a soldier sustained a mTBI or has developed PTSD. While these methods are useful, there are soldiers who do not seek medical treatment. We believe the ones that do not seek medical treatment account for a majority of the total medical costs seen today. In order to shed light on the costs of misdiagnosis, we separate out the PTSD and mTBI costs from the other medical costs. We expect to find a difference in cost between diagnosing PTSD, mTBI and a combination of both illnesses.

Purpose of This Study

The purpose of this research is to evaluate the costs of misdiagnosing mTBI and PTSD. The object of this effort is a cost model which will outline the different costs for treating PTSD and mTBI as well as the costs of treating PTSD with mTBI. Our goal is for the cost model to enable better decision making regarding treatments when the presentation of symptoms is ambiguous. In order to assess the costs of misdiagnosing PTSD and mTBI, we answer the questions outlined in the following section.

Research Question

What are the near-term monetary costs of treating active duty personnel with mTBI and PTSD?

Hypothesis

Failing to diagnose and treat mTBIs increases lifetime monetary costs over the money saved by treating a false positive mTBI.

Implications

This research sheds light on the costs of misdiagnosing mTBIs and has the potential to bring about change. The cost model could have potential service-wide and worldwide implications. Doctors throughout the service and civilian sector may not realize the costs associated with misdiagnosing a patient. By characterizing the typical treatment decisions made as a result of diagnostic choices, the model will show the near and long term costs linked with the doctor's decisions. A new understanding of the cost of misdiagnosis may reduce long-term medical costs and, as a result, may increase the percentage of proper diagnoses.

Preview

Discussion will begin with existing literature on PTSD and mTBI and the methods used to diagnose a patient. We will analyze 2007 and 2008 medical cost data and determine the costs for PTSD and mTBI. We will also discuss the applicability for service and worldwide use, as well as propose recommendations to facilitate analyzing misdiagnosis costs in the future.

Chapter II: Literature Review

In this chapter, we provide the reader with a general overview of PTSD and mTBI. We discuss the critical components of the misdiagnosis of PTSD with mTBI. We also offer background and general discussion on previous research and how the previous research applies to our current research.

TBI Overview

There are different types of brain injuries that can occur. A penetrating injury occurs when an object pierces the skull and enters brain tissue. A closed head injury occurs when the head hits an object but the object does not break through the skull, resulting in rapid acceleration and deceleration of the brain. A blast exposure can also cause a non-penetrating injury due to the blast wave transmitting through the brain (Tanielian & Jaycox, 2008).

There are also different phases of blasts. Due to the changes in atmospheric pressure; "a high-explosive detonation results from the nearly instantaneous conversion of a solid or liquid into gasses. Momentarily, these gasses occupy the same volume as the parent solid or liquid and thus they are under extremely high pressure. The gasses expand rapidly, causing compression in the surrounding air, forming a pulse of pressure" such as in Figure 1 (Taber, Warden, & Hurley, 2006). The pressure will drop as the gasses continue to expand which creates a relative vacuum (blast under pressure, negative phase of the blast wave). The blast creates a massive swing in the pressures placed on the body which results in both shear and stress waves. These waves create forces that affect bodily organs and tissues and can cause secondary and tertiary blast injuries. A secondary blast injury occurs when objects impact a person, which is also known as ballistic trauma, and tertiary blast injury occurs when a person is thrown into solid objects.

Figure 1 explains the sequence of changes in atmospheric pressure following an explosion which make up the blast wave. Prior to the explosion (1), pressure is normal. With the passage of the shock front (2), the blast forces are maximal and the wind flows away from the explosion (2, arrow). This is followed by a drop in atmospheric pressure to below normal (3), resulting in the reversusd blast wind (3, arrow). Atmospheric pressure returns to normal after the blast wave subsides (4) (Taber, Warden, & Hurley, 2006).

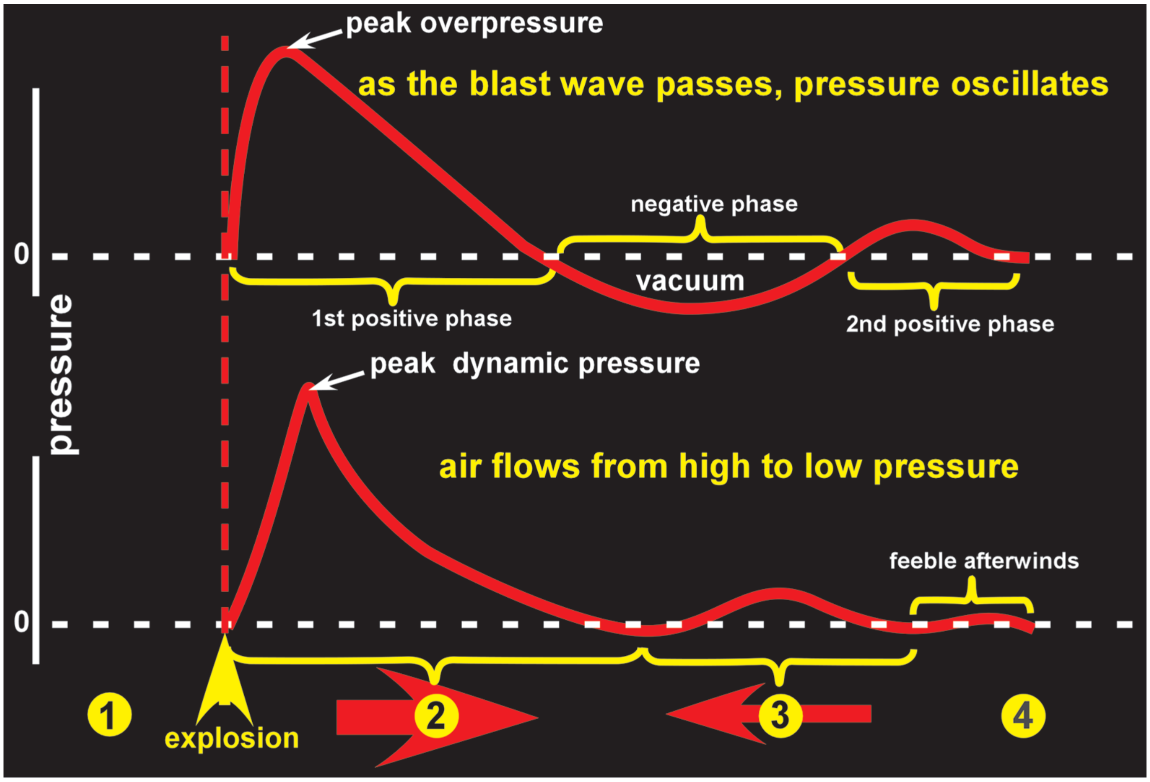

Figure 1: Effects of a Blast Wave
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The environment surrounding the situation also factors into a service member's injuries. For example, explosions near or within hard solid surfaces become amplified two to nine times because of shock-wave reflection (Rice & Heck, 2000). Moreover, victims positioned between the blast and buildings often suffer 2–3 times the degree of injury of a person in an open space. Indeed, people exposed to explosion rarely experience the idealized pressure-wave form, known as the Friedländer wave. Even in open-field conditions, the blast wave reflects from the ground, generating reflective waves that interact with the primary wave and thus changing its characteristics. In a closed environment (such as a building, an urban setting, or a vehicle), the blast wave interacts with surrounding structures and creates multiple wave reflections, which, interacting with the primary wave and between each other, generate a complex wave ((Mainiero & Sapko, 1996); (Ben-Dor, Igra, & Elperin, 2001)).

Due to blast effects, doctors use the Glasgow Coma Scale to measure the severity of the TBI, which assesses a patient's eye opening, motor, and verbal response. Two other measures for TBI severity are the length of loss of consciousness and length of post-traumatic amnesia (Tanielian & Jaycox, 2008). The Glasgow Coma Scale is a 1-15 scale with one being the most severe and fifteen being the least severe. The TBI definition proposed by the American Congress of Rehabilitation Medicine includes (1) associated diminished or altered state of or loss of consciousness (LOC), i.e., interruption of awareness of oneself and surroundings for less than 30 minutes; (2) posttraumatic amnesia (PTA), i.e., memory disruption following injury (not able to store or retrieve new information) for less than 24 hours, and (3) a Glasgow Coma Scale score of 13 or greater quantifying level of consciousness (Harrington, et al., 1993).

Moderate to severe TBIs are evident in neuroimaging data and doctors have observed and documented periods of loss of consciousness (LOC). However, there is no single diagnosis tool for TBI that is sensitive to all levels of severity and chronicity. By definition, patients with mild TBI have normal findings on clinical neuroimaging. In the absence of abnormal neuroimaging, medically observed and documented loss or alteration of consciousness is the most commonly used criterion measure for the presence of brain injury (Belanger, Uomoto, & Vanderploeg, 2009). Due to the lack of physical evidence, doctors may overlook mTBIs.

There are many different reasons a soldier could report an alteration in consciousness, such as an adrenaline rush or emotional issues, which makes proper diagnosis even more difficult. An alteration in consciousness may not be a LOC. For example, a soldier could have had an alteration of consciousness and during this time new memories may not have been consolidated because of posttraumatic disorientation. Also, symptoms may be due to a residual postconcussion syndrome (PCS) related to a mild TBI, but false positive errors would result if current symptoms are due to other postdeployment conditions such as PTSD, depression, substance abuse, chronic sleep disorder, and/or chronic pain (Belanger, Uomoto, & Vanderploeg, 2009).

There are many different symptoms associated with mTBI as seen in Table 1.

Table 1: Mild Traumatic Brain Injury Symptoms

attention	loss of motor skills	dizziness	ringing in the ears
concentration	balance	depression	Vomiting
problems learning new things	seizures	anxiety	Guilt
poor memory	mental fatigue	sleep problems	Nausea
explosive temper	reading problems	irritability	inconsideration
Slowed reasoning	feelings of helplessness	drowsiness	headache
withdrawal from social activities	writing problems	anger	speed of information processing
self-awareness	poor judgment	blurred vision	confusion

The Rand Corporation conducted a study on soldiers who reported injuries with a LOC and/or altered mental status during their deployment. From this study, Rand reported that 19.5% of soldiers sustained a probable mTBI. (Tanielian & Jaycox, 2008). Hoge et al reported a similar finding of 15% of probable mTBI during a deployment (Hoge, Castro, Messer, McGurk, Cotting, & Koffman, 2004). Even though these findings are high, there are still solders that may not know they sustained mTBI and the injury goes unreported.

PTSD Overview

It is likely that an individual will experience at least one traumatic event in their lifetime. People react to traumatic situations differently and typically, most people are able to overcome the experience and move on with their lives. However, some may suffer for years. According to a study conducted by Dr. Breslau, a high proportion of persons with PTSD (approximately 82%) meet Diagnostic and Statistical Manual Fourth Edition (DSM-IV) criteria of having PTSD symptoms for at least three months. In addition, approximately 74% continue to have symptoms for six months or more (Breslau, 2001). Military rates of PTSD are different from civilian rates because of the nature of a military profession. During combat, military members can face numerous traumatic events that can prolong their recovery time.

Surveys of military personnel returning from deployments to Iraq and Afghanistan have shown that the prevalence rates of PTSD range from 8% to 16% (Tanielian & Jaycox, 2008). However, some soldiers do not seek medical treatment for fear of reprisal, which can skew the statistics. PTSD in essence develops when symptoms fail to resolve after some psychological trauma, which is why prompt treatment is critical to helping patients recover faster.

PTSD as defined in the DSM-IV Text Revised, is an anxiety disorder encompassing four major criteria:

1. Exposure to or witnessing an event that is threatening to one's well-being and responding with intense fear, helplessness, or horror

2. Symptoms of reexperiencing, such as recurrent and intrusive memories, nightmares, a sense of reliving the trauma, or psychological and physiological distress when reminded of aspects of the trauma
3. Avoidance of thoughts, feelings, or reminders of the trauma, and the inability to recall parts of the trauma, withdrawal, and emotional numbing
4. Arousal increases, as manifested in sleep disturbance, irritability, difficulty concentrating, hypervigilance, or exaggerated startle response

In addition to the four criteria, there are many other symptoms associated with PTSD as seen in Table 2.

Table 2: PTSD Symptoms

intrusive sensations and cognitions	exhaustion
emotional numbing	insomnia
avoidance	headaches
physiological hyperarousal	startle response
memory disturbances	reduced relational intimacy
attention	noise sensitivity
concentration	fatigue
irritability	increased sensitivity to light
impaired decision making	anxiety

There are many different risk factors involved when a person has PTSD. Assessment of suicidal risk is important because there is evidence of a positive association between the number of previous traumatic events and the likelihood of a suicide attempt (Friedman, 2006). Two different studies using a National Comorbidity

Survey indicate, “persons with lifetime PTSD were significantly more likely to report having thought about killing themselves and to have made an attempt, even after accounting for a variety of potential sociodemographic and mental health confounding factors (Tanielian & Jaycox, 2008) (Kessler, Borges, and Walters, 1999; Sareen et al., 2005). The individual with PTSD may be a threat to others if they become violent or engage in risky behaviors. Some individuals may turn to drugs and/or alcohol to cope with the traumatic experience. Everyone differs in his or her reaction to a traumatic event and some may be able to cope better than others can. It is important that these individuals receive social support in order to help with the healing process.

Comorbid Symptoms

Comorbid symptoms create challenges when evaluating patients. Many factors tend to co-occur with mild TBI and can complicate both assessment and treatment. These factors include preexisting stress and social difficulties, learning disabilities, history or previous neurologic or psychiatric disorders, and preinjury alcohol or drug abuse (Belanger, Uomoto, & Vanderploeg, 2009). The RAND study reported a high rate (33%) of co-occurrence between a history of mTBI, PTSD, and depression.

In practice, the clinical distinction between PTSD and mTBI relies on the predominant symptoms. When a patient has more organic symptoms such as headache, dizziness, visual complaints, hearing loss, balance problems, and cognitive disturbance, the patient is thought to have post-concussion syndrome. However, PTSD typically manifests when the predominant features are symptoms such as nightmares, hyperarousal, avoidance, and reexperiencing phenomena (Elder & Cristian, 2009). Consequently, the time interval between the event and the assessment is critical in the diagnosis of PTSD and/or mTBI. However, some individuals who experience a traumatic event may not report their injury right away and it could even be years before a doctor sees a soldier. For properly diagnosing mTBI, it is extremely important to document the symptoms that occur at the time of the event (i.e. LOC, altered consciousness). There is potential for a significant gap in time from incident to assessment and doctors may never know if there was a true LOC or just an altered state of consciousness, which makes proper diagnoses difficult. While most mTBIs resolve on their own, 10-15% of persons with mTBI develop postconcussive symptoms (PCS) (McCrea, 2008). If PCS symptoms are not treated, they could become Persistent Postconcussive Symptoms (PPCS) as shown in Figure 2. We modeled Figure 2 after a figure in the article Exploring the Convergence of PTSD and mTBI.

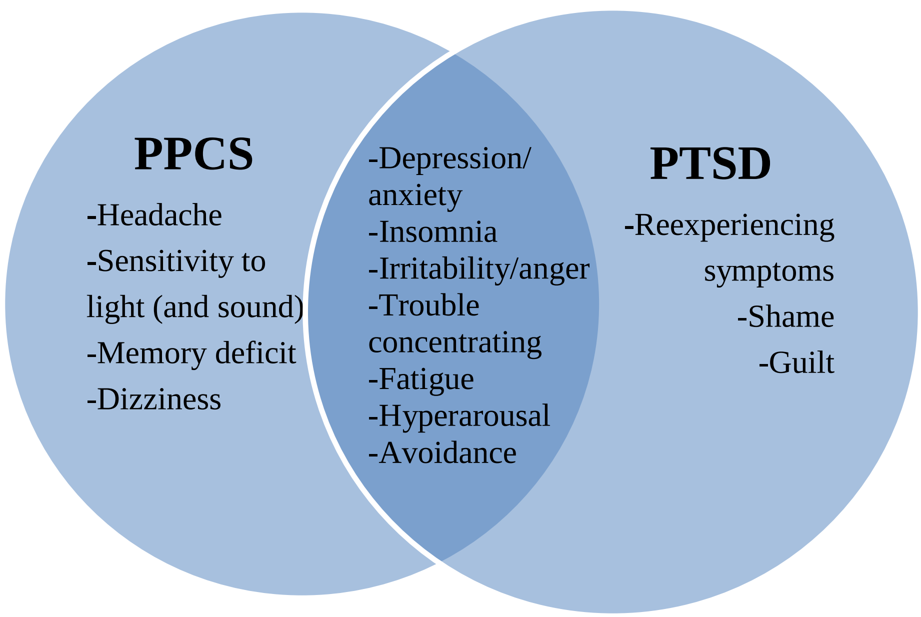

Figure 2: Interface of PTSD and Persistent Postconcussive Symptoms (PPCS) following MTBI

Schneiderman et al conducted a study and found that about 12% of more than 2,200 veterans who returned from Iraq and Afghanistan reported a history consistent with mTBI, and 11% screened positive for PTSD (Schneiderman, Braver, & Kang). It is interesting that the risk of PTSD almost doubled due to combat related mTBI. The strongest factor associated with persistent postconcussive symptoms was PTSD. Even after removing the overlapping symptoms in Figure 2 from the PTSD score, the association between postconcussive and PTSD symptoms remained strong (Stein & McAllister, 2009).

Vanderploeg et al conducted a study with Vietnam-era veterans to determine the associations of various symptoms and psychiatric diagnosis with a remote history of mTBI and a current diagnosis of PTSD. Vanderploeg et al found that sixteen years after combat 68.6% of the Motor Vehicle Crash (MVC) injury control group no longer met criteria for PTSD (significant at $p < .05$). In contrast, in the mTBI group, only 47.5% resolved (Vanderploeg, Belanger, & Curtiss, 2009). Vanderploeg's article demonstrates that mTBI adversely affects the potential recovery of PTSD. With early intervention, these statistics can improve.

Hoge et al reported that 43.9% of soldiers who had symptoms associated with LOC also met the criteria for PTSD. However, after adjusting for PTSD and depression, mTBI was no longer significantly associated with PCS symptoms (except headache) and physical health outcomes. These authors suggest that the high rates of physical health problems reported by soldiers with mTBI are mediated largely or entirely by PTSD or depression rather than the mTBI (Belanger, Uomoto, & Vanderploeg, 2009). Belanger et al believe that in the OEF/OIF population, even poor performance on neuropsychological tests may be more associated with deployment-related stress or PTSD than with mTBI. Some military doctors believe that mTBI is simply a concussion and doctors need to treat it as such because the real health issue is either PTSD or depression. Misattribution of symptoms to a residual TBI when such symptoms are secondary to stress, chronic sleep deprivation, PTSD or other mental health condition, for example, could iatrogenically reinforce the misconception that these symptoms are permanent (Belanger, Uomoto, & Vanderploeg, 2009). Doctors such as Richard Bryant believe that mTBI has been mistaken for PTSD or depression and that the impairment observed in the aftermath of mild traumatic brain injury may be incorrectly attributed to psychological distress, rather than neurologic insult (Bryant, 2008). Bryant also mentioned a study that found that psychological factors play a significant role in postconcussive symptoms and these symptoms occur at similar rates in persons with mTBI and those with no TBI.

Mild TBI may not always be PTSD or depression though, which leads to another idea of mTBIs and the significance of properly diagnosing them. Dismissing the mTBIs and treating patients for PTSD can create a magnitude of problems when treating patients. Patients who have mTBIs may develop psychological disorders such as PTSD or depression in the future, which leads to two theories. The first theory is that the combination of the comorbid conditions such as PTSD and depression cause the persistent symptoms of the mTBI. The second is that the mTBI was not properly treated which led to other problems such as PTSD. Either way, the delayed onset of symptoms may cause problems in diagnosing both PTSD and mTBI.

The relationship between PTSD and TBI is interesting to military doctors around the world. TBI is a classic example of an organic brain disease and PTSD is a psychologically based reaction to a stressor that was not associated with physical injury. Some medics suggest that TBIs protect patients from PTSD because the blackout period prevents the psychological trauma from occurring. However, because service personnel in a war zone inevitably have exposure to PTSD stressors independent of TBI events, the coexistence of the two disorders is easy to imagine (Elder & Cristian, 2009).

The distinction between these two disorders affects both treatment strategies and patient education. The PTSD reaction is an abnormally sustained stress response. PTSD treatment focuses on normalization of these stress reactions through psychologically-based therapies as well as pharmacologically-based treatments. On the other hand, the TBI treatment framework is more of an organic model. This model assumes that structural brain alterations have occurred and that recovery depends on neurological factors, with treatment focused on improving attention and concentration with agents such as psychostimulants or improving compensatory strategies through cognitive/behavioral therapies (Elder & Cristian, 2009).

Another possibility regarding the interface of PTSD and TBI is that TBI may influence the development of PTSD. Mild TBI's can impair the cognitive abilities that are necessary to manage the repercussions of a psychological trauma. Hoge et al speculates that TBI's might impair these cognitive abilities by damaging the brain structures that are thought to be critical in PTSD (Elder & Cristian, 2009) (Hoge, Thomas, Cox, Engel, & Castro, 2008). Figure 3 shows how the presence of TBI can influence the presence of PTSD. Schneiderman et al and Hoge et al both conducted studies in 2008 of military personnel post-deployment. These studies show the linkage between combat-related TBI and an increased incidence of PTSD. Hoge's findings were statistically significant in that the 43.9% of soldiers who lost consciousness also met the criteria for PTSD (p-value of .001) (Hoge, Thomas, Cox, Engel, & Castro, 2008).

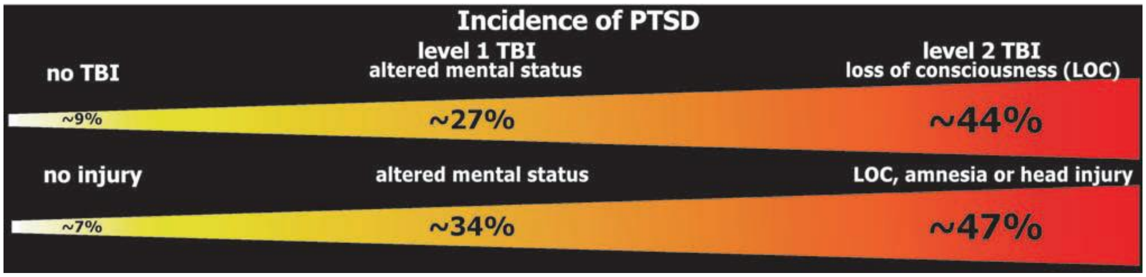

Figure 3: Association Between PTSD and TBI
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In the war zone soldiers are taught to be hypervigilent. The amygdala, a complex structure involved in a wide range of normal behavioral functions and psychiatric conditions, is responsible for increased reflexes and thus during combat soldiers have a hyperactive amygdala (LeDoux, 2008). When their tour is over, the soldiers return home and are to shut off their hypervigilance, combat ready state of mind. PTSD severely disrupts the normal restraint on the amygdala and soldiers are unable to lead their lives the way they did before they deployed (Friedman, 2006).

PTSD may relate to the type of brain injury sustained. Certain areas of the brain are more susceptible to damage from a blast. This is particularly true for cortical areas vulnerable to blast injury transfer through the skull or the ‘soft-tissue portals’ of the skull. The role of these cortex areas is to inhibit structures just below the cortex and to integrate information. Damage to susceptible cortical areas, in particular to the prefrontal and temporal cortices, can lead to lack of restraint of the brain structures that regulate fear and anxiety responses (Wrathall et al., 2009).

There have been numerous functional imaging studies conducted in order to determine what areas of the brain PTSD, TBI, and both affect. When a patient has PTSD, the amygdala becomes overactive and the cortical regions become underactive. With these data in mind, it should be possible to make neuroanatomically specific hypothesis about the risk of PTSD depending on the location of brain lesions (Stein & McAllister, 2009). This is just one way to help decode the comorbidities involved with mTBIs and PTSD, but it may not be feasible on a large scale. It would be difficult and costly to screen every soldier returning from Iraq and Afghanistan.

Screening

The three common methods to identify "caseness" (i.e., who has a disease or disorder, referred to as *cases*, and who does not) in psychiatric epidemiology are: diagnostic codes from case registries among individuals in *treatment contact* (i.e., receiving some type of medical care); screening tools that identify persons with probable disorders; and diagnostic interviews that assign actual diagnoses based on criteria set forth in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) [American Psychiatric Association, 2000] or *International Classification of Diseases* (ICD) (Tanielian & Jaycox, 2008). Each tool has its benefits but almost all screening tools have a tradeoff between sensitivity and specificity, which determine the tools' validity. The sensitivity is the proportion of persons with a given condition correctly identified by the screening tool as having the condition and the specificity is the proportion of persons without a condition correctly identified by the screening tool as not having the condition. The tools for detecting a mTBI and PTSD can either identify all possible cases or only identify true cases or something in between the two (Tanielian & Jaycox, 2008). The researcher asks experts what their goal is when detecting mTBI and PTSD and creates a tool based on the experts needs.

Questionnaires

The Department of Defense and the Department of Veterans Affairs have implemented new screening measures in light of the recent attention to the "signature wounds of war." The Air Force conducts the Periodic Health Assessment (PHA) once a year to ensure Airmen are physically and mentally ready for combat. Before a member can deploy they must complete a Pre-Deployment Health Assessment (PDHA) within sixty days prior to deployment. This assessment identifies any health concerns that need addressed before the member's deployment. The servicemember must complete the PDHA within thirty days before and after deployment. The PDHA identifies any mental or physical health concerns associated with deployments as well as deployment-related occupational or environmental exposures. In 2005, the Post-Deployment Health Re-Assessment (PDHRA) was initiated to focus on servicemembers' health concerns that emerge over time after their return from deployment. The military administers the PDHRA ninety to one hundred and eighty days after the members return from deployment (GAO, 2008). Effective June 1, 2007 the DoD added TBI screening questions to the PHA, PDHA and the PDHRA.

The questions added to the PDHA are cognitive assessment questions that help determine if there is a problem with abilities such as memory and reaction time. The sequence of questions specifically assesses (a) events that may have increased the risk of a TBI, (b) immediate symptoms following the event, (c) new or worsening symptoms following the event, and (d) current symptoms. If there is a positive response to any question in the first series, the servicemember completes the second and third series; if there is a positive response to any question in the third series, the servicemember completes the fourth series about current symptoms. The PDHA directs the health care provider to refer the servicemember based on the servicemember's current symptoms (GAO, 2008). See Figure 4 for the screening questions for the PDHA; the PHA questions are similar but do not reflect the servicemember's deployment.

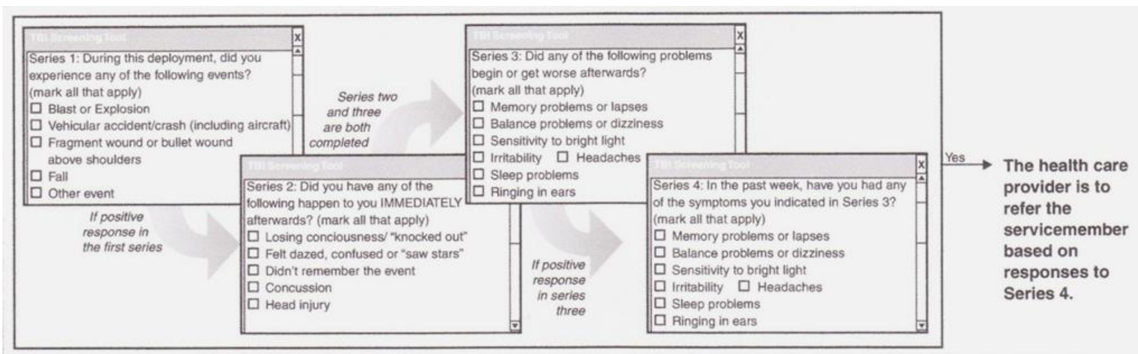

Figure 4: TBI Screening Questions on the PDHA
Source: GAO Analysis of DoD Screening Questions

The Warrior Administered Retrospective Casualty Assessment Tool (WARCAT) is a relatively new tool developed at Fort Carson, Colorado. The WARCAT is a questionnaire that enables soldiers to indicate whether they were injured from mechanisms commonly associated with TBI while deployed, whether any injuries resulted in an altered mental status indicative of TBI, and/or whether specific somatic and neuropsychiatric symptoms commonly associated with mild TBI occurred after the injury (immediately postinjury and/or postdeployment) (Terrio, et al., 2009).

The Defense and Veterans Brain Injury Center (DVBIC) created a three-question TBI screening tool that the military is using to screen returning OEF/OIF servicemembers for TBI. The Brief Traumatic Brain Injury Screen (BTBIS) has demonstrated a positive value for predicting TBI in the OEF/OIF population (Schwab, Baker, Ivins, Sluss-Tiller, Lux, & Warden, 2006). However, this tool has yet to be validated against actual clinical diagnoses. While the screening is of value, simply meeting the criteria does not require current TBI related injuries and it may not assess ongoing trauma related impairments.

Due to the increase rate of missed cases, DVBIC developed a tool for determining cognitive deficits due to mTBI. The main goals of the Military Acute Concussion Evaluation (MACE) are to confirm the diagnosis of mTBI, and to provide further assessment data by using the Standard Assessment of Concussion to record neurocognitive deficits (McCrea et al., 1997). Medics and/or corpsmen can easily administer MACE within five minutes and the evaluation consists of thirteen items (8 history items and 5 examination items) (Elder & Cristian, 2009). The history items are to capture the details of the incident and enable the medical staff to provide a score of 1-30. Scores below 25 may be indicative of cognitive impairment (DVBIC).

The military uses the 17-item National Center for PTSD Checklist, which is an instrument that contains seventeen symptom items keyed directly to the DSM-IV. Symptoms receive a score according to the DSM-IV definition for PTSD. A patient will test positive if they meet the DSM-IV criteria, which includes one intrusion symptom, three avoidance symptoms, and two hyperarousal symptoms. However, there are problems with the screening tools we use to assess both PTSD and mTBI.

Problems with Screening Tools

Table 3 provides a visual overview of the screening tools and the problems associated with the tools.

Table 3: Overview of mTBIand PTSD Screening Tools

Screening Tool	Target Group	Effectiveness	Who is missed
PHA/PDHA/ PDHRA	All members of the military receive PHA annually, PDHA before and after deployment, and PDHRA after deployment	As of 2007, less than 0.5% of active duty AF members who have deployed receive a diagnosis of PTSD and approximately 1% screen positive for TBI	Some Reserve and Guard members
WARCAT	Not a DoD wide program. Only some Army personnel receive this assessment	It is under a study protocol evaluation to see if it can be validated	Most military personnel
BTBIS	Soldiers returning from Iraq and Afghanistan	Not validated	Soldiers who returned before 2006
MACE	In theater	Validation for In-Theater Evaluation of Combat-Related Traumatic Brain Injury is pending IRB approval	Medic and/or corpsmen discretion
PTSD 17-item checklist	Self report	According to Weathers et al the checklist has good sensitivity (.82) and specificity (.83) in correctly identifying subjects' PTSD diagnostic status when a score of 50 or more is used as a cut-point*	Soldiers who do not seek medical attention for PTSD like symptoms

Absence of evidence is not proof of absence, which hinders the effectiveness of any screening method. However, the screening tools the military uses are not perfect. Colonel Hoge of the Walter Reed Army Institute of Research presented a briefing in February 2009 on PTSD Screening Among Service Members Returning from Iraq and Afghanistan. He discussed the 17-item PTSD checklist (PCL) and the Post-deployment Health Assessments utilizing PC-PTSD screen and noted the utilization data are not reliable for PTSD surveillance. He found that different cutpoint numbers for the PCL resulted in different sensitivity ranges. The higher the cutpoint, the higher percentage of people who screen positive will actually have PTSD as seen in Figure 5. The lower cutpoints use many resources for unnecessary evaluations; however, they make sense for clinical screening. Colonel Hoge stated, "the higher cutpoints are required for surveillance population prevalence estimates, and for screening on a population-level" (Hoge C. W., PTSD Screening Among Service Members Returning from Iraq and Afghanistan, 2009).

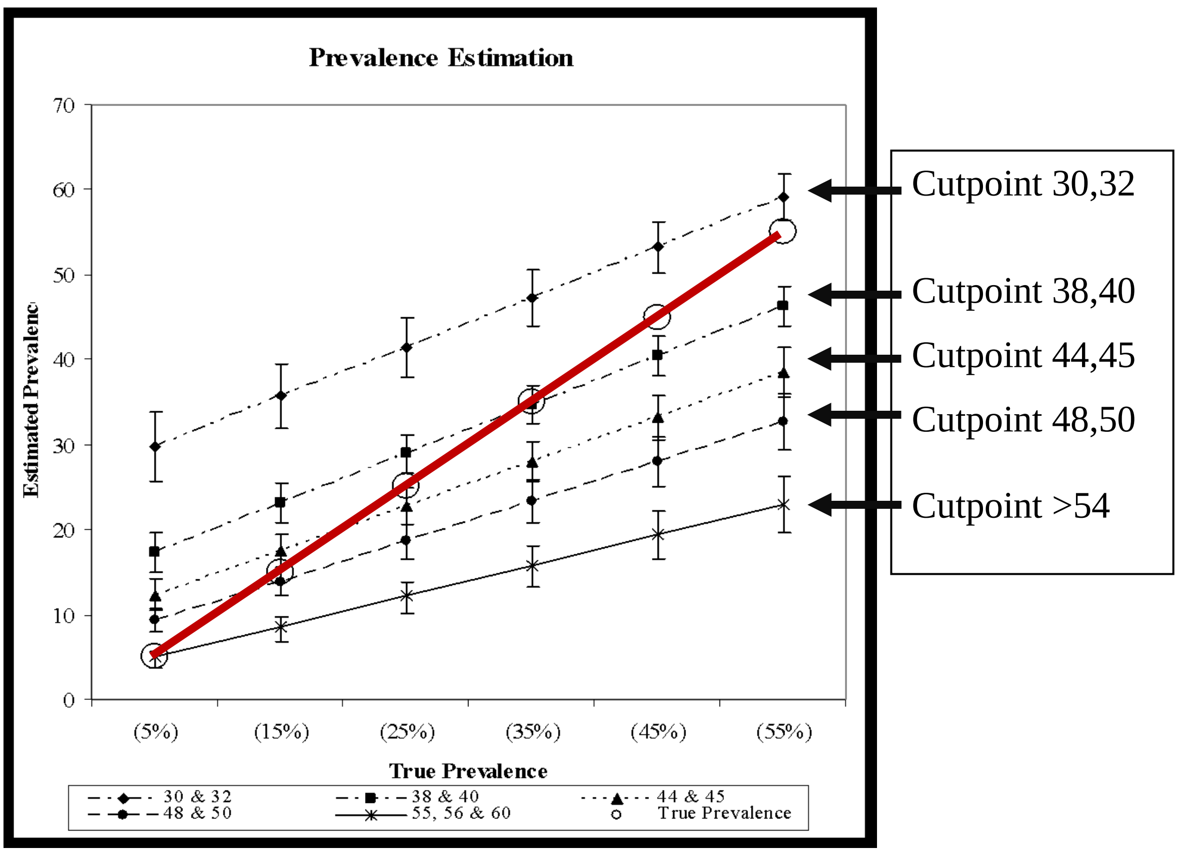

Figure 5: Estimated Prevalence of PTSD versus True Prevalence
Source: Col Hoge's PTSD Screening Among Service Members Returning from Iraq and Afghanistan Briefing

Screening tools are inevitably wrong because researchers do not have the time to measure the entire population. Researchers administer these tools to subsamples, providing us with inaccurate estimates of prevalence. However, we do not have a better, cost effective option to identify individuals who might have a medical condition and need treatment. There is an option that may improve the prevalence rates and that option is interviews.

Interviews

Another method of screening is structured interviews. Frequently, the clinician's best option is to ask the patient to provide a detailed account of the event, thereby assessing for gaps in memory for the event, or asking the patient what he was informed about his or her behavior or mental state by military colleagues who observed him or her at the site (Belanger, Uomoto, & Vanderploeg, 2009). Interviews are beneficial because they allow doctors to gather more information than simply a yes or no answer on a questionnaire. With this additional information, doctors can make a better assessment of the symptoms and severity of the injury or disorder.

Treatments

There is very little research conducted regarding the treatment of comorbid conditions. However, the Rand study briefly covers the treatment of co-morbid symptoms and they determined that providers who assess patients with mTBI and PTSD symptoms must determine the proper *sequence* of treatment to implement (Belanger, Uomoto, & Vanderploeg, 2009). For example, an OEF/OIF veteran with severe symptoms of PTSD may not be ready to participate in comprehensive post-acute polytrauma/TBI rehabilitation services and hence may first benefit from stabilization of emotional problems secondary to PTSD or other mental health conditions (Tanielian & Jaycox, 2008). Treatment for PTSD may require modification given the potential interference of TBI-related cognitive compromise, especially in the immediate aftermath of a concussion (Nelson, Yoash-Gantz, Pickett, & Campbell, 2009).

"A frank neurologic insult such as TBI may exacerbate PTSD symptoms because of a greater inability to self-regulate and inhibit behavioral responses" (Nelson, Yoash-Gantz, Pickett, & Campbell, 2009). Nevertheless, it is important to note that mTBI symptoms are not always chronic and with the right treatment, a patient may not develop PTSD. The majority of cognitive symptoms associated with mTBI disappear after one month of injury. Nevertheless, the military must be able to meet the needs of the minority of patients with prolonged mTBI symptoms because recovery is a gradual process that occurs for at least 18-36 months as the brain recovers and regenerates.

Cost

The Invisible Wounds of War RAND Report studied the treatment and rehabilitation costs for PTSD, depression, and TBI as well as the medical costs associated with suicide attempts and completions, the value of lives lost to suicide, the value of lives lost to TBI and the lost productivity stemming from PTSD, depression and TBI. RAND's goal was to project 2-year post-deployment costs associated with PTSD and depression. Their goal for TBI was to calculate the total costs associated with TBI in 2005. RAND choose a microsimulation approach for determining the costs for PTSD and depression with three different treatment pathways: usual care, evidence-based care, and no care. On average, individuals receiving evidence-based treatment have a higher probability of remission than individuals receiving usual care, who in turn have a higher probability of remission than those receiving no care (Tanielian & Jaycox, 2008). RAND predicted the baseline two-year costs per case of on E-5 with PTSD and receiving no care to be $11,986. With usual care, the cost increased to $13,935 but with evidence-based care, the cost dropped to $7,933 FY08 dollars. With microsimulation models, the model results can be extremely dependent on the constraints used to assign event probabilities. Thus, any deviation from these constraints can cause the results to be misleading.

RAND calculated TBI costs based on civilian populations because they were unable to collect any TBI data from the military or the VA. RAND chose three categories of treatment to estimate the cost of TBI: acute hospital care, inpatient rehabilitation, and outpatient rehabilitation. They predicted high and low costs. The high cost for mTBI acute hospital care was $21,346 and the low was $15,144 (FY05 dollars). The inpatient rehabilitation costs for mTBI was not applicable while outpatient costs were $1,487 and $618 for high and low, respectively. Since RAND could not obtain military cost information, these costs cannot directly correlate to the military population.

In FY 1992, Ommaya et al conducted a review to identify head injury admissions using incidence rates, case fatality rates, causes of head injuries, and direct cost for hospital admissions. Ommaya et al examined hospital discharge records and private facilities that received reimbursement from CHAMPUS now known as TRICARE. They used the average cost per occupied bed day to determine the expenses to include the clinic proportion of total facility cost, including construction, facility expenses, professional and staff wages, equipment, and supplies. The authors then assigned costs to each patient by determining the length of stay in each clinic and intensive care unit and any days spent in civilian hospitals. Ommaya et al found 5,568 hospitalized cases of noncombat head injury in the military medical system and a total cost of $43 million in FY02 dollars. The authors concluded that there is a need to develop prospective payment mechanisms for rehabilitations and injury rehabilitation problems (Ommaya, Ommaya, Dannenberg, & Salazar, 1996).

Now that we have examined the previous research, we can develop a methodology that will answer our research questions and analyze PTSD and mTBI cost data.

Chapter III: Data Collection and Methodology

In this chapter, we describe the data and how we propose to answer each of the research questions outlined in Chapter I. Our goal is to take raw medical data and separate out the cost of treating mTBI and PTSD to see how much of the total medical costs come from mTBI and PTSD. In order to do this, we must first explain the variables and where we acquired the data for each of the variables. Then, we discuss the shortcomings of the data. Lastly, we discuss the methods that we use in Chapter IV to analyze and interpret the results.

Data Sources and Variables

The search engine ProQuest enabled us to explore the Nursing and Allied Health Source, the Pharmaceutical New Index, the ProQuest Health and Medical Complete, the Psychology Journals, and the ProQuest Medical Library database. We also utilized the search engine PubMed and if articles were not available due to limited access, Dr. Stuart Hoffman sent them to us. In brief, the overall approach used was to define mTBI, PTSD, the behavioral symptoms of each individually and combined, and the therapies for each individually and combined. We used the terms TBI, PTSD, misdiagnosing TBI and PTSD, and costs of misdiagnosing TBI and PTSD to generate English language articles.

Dependent Variables

Defining the dependent variables is critical to our research because there are many different illness codes used when determining the medical costs. Table 4 shows the main codes we will use as our dependent variables.

Table 4: PTSD and mTBI ICD-9 Codes

Illness	ICD-9 code
PTSD	309.81
Skull fracture	800.0, 800.01, 800.02, 800.49, 801.0, 801.01, 801.02, 801.06, 801.46, 801.96, 803.0, 803.01, 803.02, 803.09, 803.5, 804.0, 804.5
Concussion	850.0, 850.11, 850.5, 850.9, 851.0, 851.01, 851.02, 851.05, 851.09, 851.81, 851.86, 852.0, 852.01, 852.06, 852.09, 853.00, 853.01
Intracranial injury of other and unspecified nature	854.0, 854.01, 854.02, 854.03, 854.06, 854.09, 860.0, 860.4, 920, 958.4
Head injury unspecified	959.01, 959.09

Independent Variable

Our research explores the predictive power of average cost variables, due to multiple occurrences of specific medical diagnoses, in an attempt to predict the cost of misdiagnosing PTSD and mTBI.

Methodology

Mrs. Deirdre Baker, Project Manager, Medical Expense and Performance Reporting System (MEPRS), scrubbed medical data for the costs associated with the codes listed in Table 4. MEPRS is a worldwide Tri-Service system that aggregates uniform medical and dental facility manpower, expense, and workload data. The information is from the MHS Data Mart (M2). The military calculates financial data using a Patient Level Cost Accounting methodology and the data are only the gross financial data (by clinic or inpatient specialty). In order to allocate costs across individual patients, the military establishes rates and applies the relative value weights

(RVUs) or Diagnostic Related Group (DRG) weights to each patient. The Centers for Medicare and Medicaid Services (CMS) maintain a list of relative value weights (RVUs) for inpatient hospital care. These RVUs, known as the Diagnostic Related Group (DRG) weight, based on the primary diagnosis when the patient enters the hospital. The DRG relative value weight is located on the CMS web site (Average Cost Estimates, 2008).

The cost data we received are not broken out by a specific individual or hospital; it is by the ordered diagnoses. We have eight and four diagnoses for the inpatient and ambulatory data, respectively. Table 5 shows the different medical costs for a sample set of data for a given fiscal year (FY) and a given month (FM 1-12) with four different diagnoses (D1-D4).

Table 5: Sample Set of Data

FY	FM	D 1	D 2	D 3	D 4	Clin Salary	Lab	Other	Other An-cillary	Other Salary	Pharm	Rad	Full Cost
07	10	30981	3149	79998	V7109	$73.14	$3.10	$125.56	$0.20	$102.37	$14.66	$2.44	$321.47
07	10	30981	3149	V629	V119	$48.58	$3.10	$125.56	$0.20	$102.37	$14.66	$2.44	$296.91
08	1	30981	30742	V7109	V609	$74.98	$8.23	$110.83	$0.53	$244.94	$6.87	$1.93	$448.31
08	1	30981	30742	V7109	V629	$36.44	$8.57	$191.80	$0.48	$99.58	$10.39	$5.93	$353.19

A patient can be included in more than one line or show up multiple times in the same line in the current data. We cannot compare the FY 2007 and 2008 costs to each other without first converting the 2007 and 2008 dollars into base year (BY) 2009 dollars.

Cost Comparison Analysis

Net Present Value

We must establish some basic assumptions for cost/benefit analysis techniques. The net present value is a way of comparing the value of money now with the value of money in the future (Net Present Value, 2010). Most economic analysis models incorporate a discount rate in order to determine the required return rate of investing capital. The calculation of a discount rate is mathematically simple. If a discount rate is 5%, the present value of a good or service available in one year's time is 5% less than the present value of the same good available right now. A dollar today is worth more than a dollar in the future, because inflation erodes the buying power of the future money (Net Present Value, 2010). Discount rates, typically the Consumer Price Index (CPI), enable us to quantify the potential medical costs and benefits of paying expenses now versus later. A major portion of the medical costs in this project is direct medical costs.

Validating DoD Cost Factors

Direct Medical Costs

This research project will focus solely on direct medical costs even though direct costs include both medical and disability costs. Direct medical costs directly impact hospital finances because they are actual medical expenditures. Disability costs are associated more with retired or medically discharged military personnel and the Department of Veterans Affairs typically disburses disability payments. Thus, these costs will not be included in our research project. In addition, reimbursements to civilian facilities for military health care will not be included.

The medical cost data are from July 2007- June 2008 for all Defense Health Programs (DHPs) (Army, Navy, and Air Force). The data are from Active Duty personnel from 378 Military Treatment Facilities (MTFs) in FY08 and 341 MTFs in FY07. The number of bed days is unknown and thus we cannot assign a cost to each patient based on bed days. Then year dollars show the cost of the treatment in the year the care was received. However, we cannot compare medical costs in the year they were captured to the current year medical costs because they are not weighted the same. In order to compare the costs of medical care all dollars must be in a base year. The following section addresses normalizing direct medical costs to ensure we are comparing dollars in the same year.

Normalizing Direct Medical Costs

Inflation changes the purchasing power of money and typically, goods and services increase over time due to inflation. The Bureau of Labor Statistics (BLS) provides inflation factors for goods and services. In order to conduct analysis on our data, we must normalize the medical costs. The CPI enables us to compare prices from different years by distinguishing price increases due to inflation. One way to see these differences is to use inflation indices. However, the BLS does not have an inflation index for medical costs, so we must build one.

Table 6: CPI-M Base Year Conversion Factors (BLS.gov)

Year	Traditional CPI-Annual Index Value	Traditional CPI-HALF1	Traditional CPI-HALF2	Traditional CPI Inflation Value HALF1	Traditional CPI Inflation Value HALF 2	Medical CPI-Annual Index Value	Medical CPI-HALF1	Medical CPI-HALF2	Medical CPI Inflation Value HALF1	Medical CPI Inflation Value HALF 2	Medical CPI Normalization Factor
1999	162	160.9	163.1	1.8%	2.4%	250.6	248.6	252.6	3.5%	3.5%	1.490
2000	167.3	166	168.7	3.2%	3.4%	260.8	258.2	263.3	3.9%	4.2%	1.431
2001	171.9	171.6	172.2	3.4%	2.1%	272.8	270.1	275.4	4.6%	4.6%	1.368
2002	174.3	173.4	175.2	1.0%	1.7%	285.6	282.4	288.8	4.6%	4.9%	1.307
2003	178.1	177.5	178.6	2.4%	1.9%	297.1	294.5	299.7	4.3%	3.8%	1.256
2004	182.7	181.5	183.9	2.3%	3.0%	310.1	307.4	312.9	4.4%	4.4%	1.204
2005	188.7	186.7	190.7	2.9%	3.7%	323.2	320.6	325.9	4.3%	4.2%	1.155
2006	194.7	193.8	195.7	3.8%	2.6%	336.2	333.6	338.8	4.1%	4.0%	1.110
2007	200.08	198.54	201.62	2.4%	3.0%	351.05	347.33	354.78	4.1%	4.7%	1.063
2008	207.78	206.93	208.62	4.2%	3.5%	364.07	362.64	365.50	4.4%	3.0%	1.025
2009		205.204		-0.8%			373.29		2.9%		1.000

In order to build Figure 6, we divided the CPI-M cost index obtained from the Bureau of Labor Statistics for 1999-2008 by the inflation factor in 2009. The BLS set 1982-1984 as a base year equal to 100. If there is any increase or decrease in prices since the base year there will be an increase or decrease in the base value. For example, in Table 6, the inflation factors for years 1999 and 2009 (first half of 2009) are 250.6 and 373.29 respectively. We use Equation 1 to calculate the conversion factor to normalize then year costs to 2009 year costs:

1+ ((Base Year Index Value – Then Year Index Value) / Then Year Index Value) (1)

For example, Equation 2 calculated the normalization factor for 1999:

$$1 + ((373.29 - 250.6) / 250.6) = 1.490 \qquad (2)$$

In order to convert then year medical cost dollars into current year dollars we use Equation 3:

$$\text{Normalized Medical Cost} = \text{Weighted CPI-M} * \text{Direct Medical Cost} \qquad (3)$$

For instance, assume that the base year for an analysis is 2007. If the total medical cost to treat a patient were $3,469.90 in 2007, how much would it have cost in the first half of base year 2009 dollars (all else being equal)? The answer based on the Medical Care CPI would be 1.063*$3,469.90, or 3,688.50 base year 2009 dollars.

We are interested in the Medical Consumer Price Index (CPI-M) annual and semi-annual inflation data for 2007-2009 because these are the years represented in our medical cost dataset. Figure 6 displays the difference between traditional and medical inflation. It is necessary to use the medical inflation rates because Figure and Table 6 clearly show that medical costs rise faster that tradition inflation.

In Figure and Table 6, it is important to note the significant drop in the first half of 2009 tradition inflation data. Mr. Mark Vitner, an economist at Wells Fargo Economics Group, quoted to CNNMoney.com that "the drop in CPI is mainly due to lower gasoline prices and lower grocery store prices" (US Inflation Calculator, 2009).

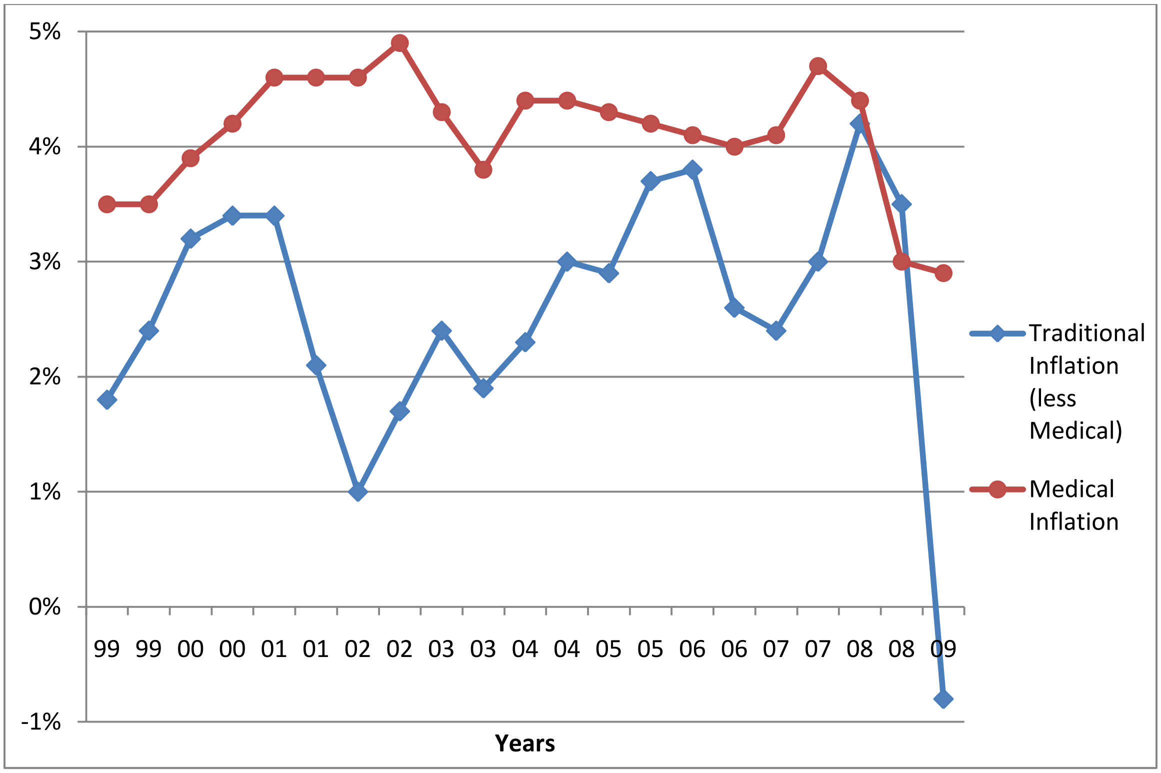

Figure 6: Semi-Annual Comparison of Medical and Traditional CPI Inflation (BLS.gov)

Inpatient versus Outpatient Medical Costs

The prior methodology enables us to develop direct medical costs resulting from PTSD and mTBI. The available data shows inpatient and ambulatory costs. Inpatient costs occur when a patient admits him or herself to a medical treatment facility and typically results in some number of bed days for a specific stay. The inpatient costs were available through MHS Data Mart (M2) but are not broken out by bed days. However, ambulatory costs do not result in bed days. These costs are the result of an illness that may not be severe enough to admit the patient, such as a routine doctor appointment or "sick call". Typically, inpatient data are more expensive than ambulatory data because a person is admitted to the MTF, which usually means the illness is more severe.

The medical cost data we received does not provide information on the severity of the illness or injury. Thus, it will be hard to decipher between a mild and moderate TBI. The medical costs associated with PTSD and mTBI must be assessed in order to determine if there is any significant different between the cases where PTSD alone is diagnosed and where PTSD and mTBI are diagnosed together.

Data Aggregation

There are many different ways to aggregate medical data, but we chose to create different groups for PTSD, mTBI, PTSD and mTBI combined, and the diagnoses associated with PTSD and/or mTBI. For example, a doctor diagnoses a patient with PTSD, depressive disorder, and amphetamine abuse. The doctor diagnoses another patient with PTSD, atypical depressive disorder, and irritable bowel syndrome. We separate out the depressive disorder, amphetamine abuse, atypical depressive disorder, and irritable bowel syndrome illnesses and document the costs so we can compare the cost of having PTSD to the cost of not having PTSD. We use this method for determining the cost of mTBI and the combination of mTBI and PTSD.

In order to compare medical costs we created an eleven-step process. Before configuring the data, we randomly selected ten percent of the data to withhold from our analysis in order to test our model. Excel associated a randomly generated value to each line of data, in which we sorted the random values and selected ten percent of the data to withhold. After separating out a portion of the data, we began the eleven-step process. Each process represents a query we ran in Microsoft Access.

Step 1: Identify each key (each line of data are a key) that contains the illness of interest (PTSD, mTBI, and a combination of the two)

Step 2: Identify all the diagnoses associated with the illness of interest

Step 3: Identify all the diagnoses not associated with the illness of interest

Step 4: Identify all the keys with at least one of the diagnoses associated with the illness of interest

Step 5: Identify which keys are not associated with the illness of interest

Step 6: Create a list of the keys associated with the illness of interest but also have at least one diagnoses not associated with the illness of interest

Step 7: Use step 6 and create a list of the keys that only have the diagnoses associated with the illness of interest

Step 8: Calculate the average cost for the illness of interest

Step 9: Calculate the average cost for the diagnoses associated with the illness of interest but do not have the illness of interest

Step 10: Calculate the average cost for all other diagnoses not associated with the illness of interest

Step 11: Calculate the average cost for the entire dataset

After analyzing the hold out, we determined the hold out portion was a good representation of the entire dataset so we expanded the dataset to include more factors. We combined the 2007 and 2008 PTSD and mTBI inpatient and outpatient data with a sample set of the 2008 outpatient population data. In order to keep track of the different sets of data we added the following columns: key, sheet, type (outpatient, inpatient), and hold out (given a zero or one). The hold out (HO) was only for the 2008 population data. Table 7 displays the columns we added in our dataset, but is only a portion of the cost data we analyzed. For a full description of the cost data, please reference Appendix 1.

Table 7 shows three lines of data from the 2008 sample set, the outpatient 2007 and 2008, and the inpatient 2007 and 2008 with their associated diagnoses and costs.

Table 7: Sample of Data Analysis

Key	PTSD	mTBI	Both	Sheet	Type	HO	FY	FM	Dx1	Dx2	Dx3	Dx4	Dx5	Dx6	Dx7	Dx8	Total Cost
1	4	4	3	2008	OP	1	8	5	V589	81601	7962						$232.66
2	4	3	2	2008	OP	1	8	6	V589	8242							$0.00
3	4	3	2	2008	OP	1	8	5	V589	8441	72690						$223.03
400361	4	5	4	OP07_08	OP	0	7	10	3102	3101	95901						$217.60
400362	5	4	4	OP07_08	OP	0	7	10	3102	71946	30981						$374.91
400363	5	4	3	OP07_08	OP	0	7	10	3102	7234	30740	30981					$349.52
462929	3	5	3	IP07_08	IP	0	8	7	8600	8052	95901	94224	3051	3510	E993	E8498	$6,108.92
462930	3	3	3	IP07_08	IP	0	8	7	8771	82030	8500	8761	8911	94128	94428	94800	$8,493.74
462931	4	4	3	IP07_08	IP	0	8	7	82330	8500	8760	9562	V4589	E9912			$15,161.94

Figure 7 provides a visual example of our cost methodology. Figure 7 demonstrates how we separated out each line of data, also known as keys. Each key has anywhere from one to eight diagnoses (DXs). The inpatient 2007 and 2008 dataset contained 3592 lines of data. The outpatient dataset contained 32,285 and 51,772 lines for 2007 and 2008, respectively. The eleven-step process separates the keys enabling us to analyze mTBI and PTSD cost information. We assigned each set of cost data we analyzed with a number as seen in the PTSD, mTBI and both columns of Table 7. These same numbers are in Figure 7.

If a key contained mTBI, we labeled that key with a number five. This also includes any diagnoses in the same key as mTBI, as long as the key contains mTBI diagnoses. For example, if the key contained mTBI, depression, and headaches, we would label the key with a five.

If a key contained diagnoses associated with mTBI but does not contain mTBI, we labeled the key with a number four. To follow along with our example, we would look for keys with depression and headaches and then label them with the number four.

We assigned the keys that contained both diagnoses associated with mTBI and diagnoses not associated with mTBI the number three. These keys do not contain mTBI. If a key contained depression, headaches, and back pains, we would label it with a three because back pains are not associated with mTBI.

We assigned everything else in the dataset a number two. Anything we did not capture in numbers three through five, we labeled as a number two as pictured in Figure 7.

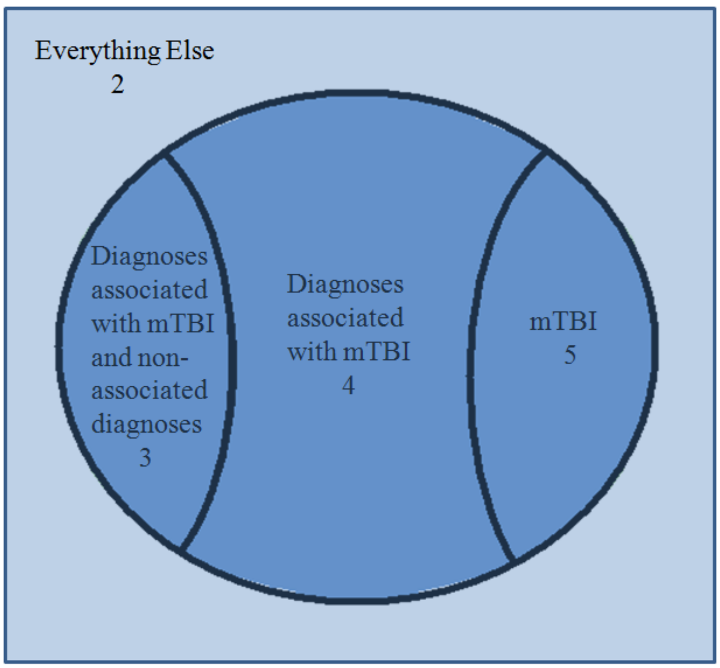

Figure 7: Process for Determining the Cost of mTBI

Using Figure 8 as an example for PTSD, the number five represents any key with PTSD. For example, a key contains PTSD, depression, and a fractured rib. This key would be a five. If another key contained the diagnoses depression and a fractured rib, the key would be given a number four. Another key may contain depression and a broken finger. This key has diagnoses associated with PTSD but also contains other diagnoses not associated with PTSD. We labeled these keys with a number three. Any key labeled with a three or four does not contain PTSD. Everything other key in the dataset not already accounted for is labeled with a number two.

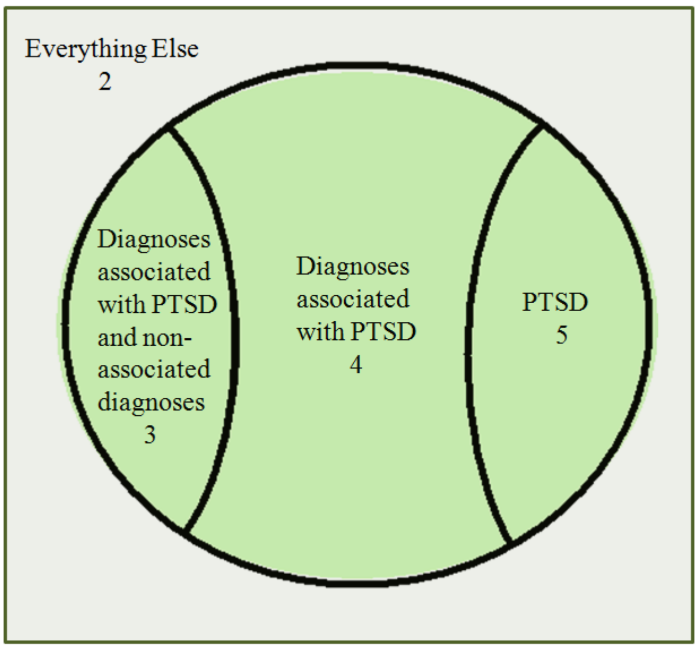

Figure 8: Process for Determining the Cost of PTSD

The numbers enabled us to change the text in a given column in Microsoft Access but keep the key the same. Thus, we made a column for PTSD, mTBI, both, mTBI only and PTSD only as seen in Table 6. Any row that contains a five in the PTSD column will have PTSD. This applies to the other columns as well. Any row that has a four in the PTSD column will have diagnoses associated with PTSD (but does not contain PTSD) and again, this applies to the other columns. Once we set up our data, we pulled out the costs for each number pictured in Figure 7 and 8.

Figure 9 explains our methodology for analyzing costs when a patient has both mTBI and PTSD. Figure 7 and 8 laid over each other creates Figure 9 and shows how we separated out mTBI costs from PTSD costs and were still able to calculate the cost of having both mTBI and PTSD. We pulled the multiple numbers (3-5) in by different queries making it easy to decipher the different costs associated with same number. By determining the cost of mTBI alone and PTSD alone, we are better able to decipher the cost of having PTSD in addition to mTBI and vice versa.

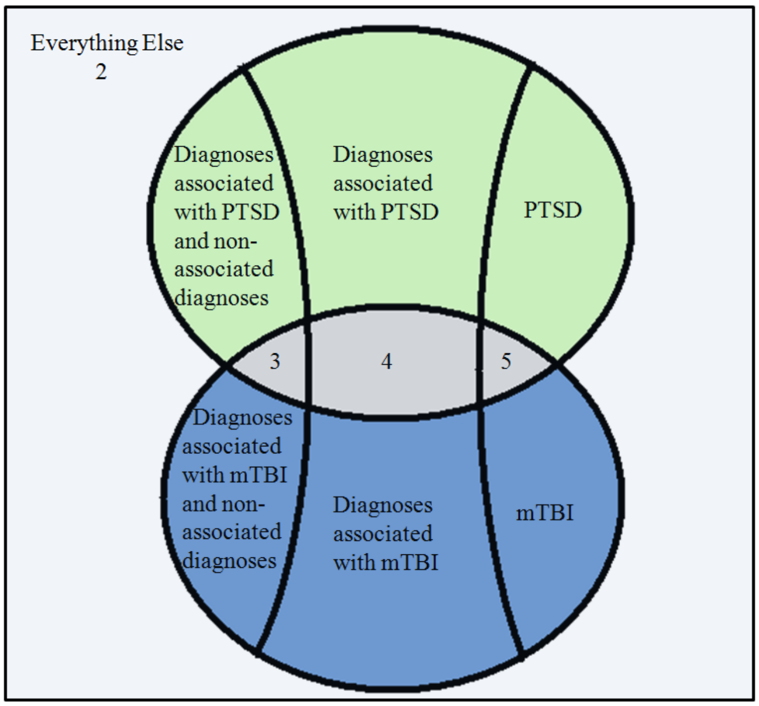

Figure 9: Process for Determining the Cost of mTBI and PTSD

We added a key count to the queries so we could see how many keys were in each number mentioned in Figure 7, 8, and 9. After running all the queries, we pulled out the important cost information. We divided the cost data by the number of encounters to obtain the average cost data. We will break out the results in the next chapter.

Testing the Means

In order to determine the validity of each query, we must test the means. We use Equation 4 to calculate the z-value:

$$Z = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{((\sigma_1^2 / n_1) + (\sigma_2^2 / n_2))}} \tag{4}$$

For Equation 4, σ_1^2 and σ_2^2 are estimated using the sample variances (s_i^2) for our sample datasets, since s_i^2 is a consistent estimator of σ_i^2.

Once we obtain the z-value, we use the conversion table to convert the z-value into a p-value and determine if our means are statistically different. We assume $\mu_1 - \mu_2$ is zero in order to determine if there is a statistical difference in the means. Our null hypothesis is $\mu_1 = \mu_2$ and our alternative hypothesis is $\mu_1 \neq \mu_2$. By using an alpha of 0.1, any z-value greater than ± 1.645 enables us to reject the null hypothesis. If any p-values are greater than the significance level, (0.1), we cannot reject the null hypothesis.

Chapter Summary

In this chapter, we discussed how we collected and manipulated data into a usable form. First, we converted all medical costs into BY09$. Then we withheld ten percent of our data to ensure our model worked properly. After determining the hold out data was a good representation of our dataset, we added more factors and ran the model again. Once we calculated the average costs, we had our results. In Chapter IV, we discuss more on how we use each model to specifically address the research questions mentioned in Chapter I.

Chapter IV: Analysis and Results

In this chapter, we provide analysis and results for each of the research questions detailed in Chapter I. First, we explain the outpatient costs for PTSD, mTBI, and both combined. Second, we explain the inpatient costs and our findings. Third, we compare the 2007 and 2008 costs for PTSD, mTBI, and both combined to the population sample data to determine if the specified illnesses account for a majority of the total medical costs that occur each year.

Medical Costs

As mentioned in Chapter III, we broke the medical costs out by mTBI, PTSD, and both for our inpatient and outpatient dataset. The outpatient Figures below display the costs for the 2007 and 2008 outpatient data as well as the 2008 outpatient population data. The inpatient Figures only display the 2007 and 2008 inpatient data because we could not obtain the 2008 inpatient population data.

Outpatient PTSD Costs

We want to determine how much PTSD is actually costing the DoD over a two year period and Table 8 shows all the 2007 and 2008 outpatient PTSD costs. The average cost of PTSD is $340 per incidence. During the two-year period, 66,619 patients were treated for PTSD and incurred a cost of $22.6 million. Assuming the number of outpatient PTSD incidences are consistent throughout the war from 2003-2010, the DoD will incur a bill of $90.6 million for PTSD alone. There are also long-term implications and costs associated with PTSD, but we could not capture these costs using our dataset.

While the diagnoses associated with PTSD and non-associated diagnoses and the costs of the dataset containing all other diagnoses not related to PTSD were higher, there were fewer incidences. Based on the p-value, there is a statistical difference between the average cost of treating PTSD and the average cost of treating every other diagnosis not related to PTSD, see Appendix 6. It is important to have the average costs of treating PTSD statistically different from the costs we are comparing them to because the difference is unlikely to have occurred by chance.

Table 8: PTSD Outpatient Average and Total Costs

Query	OP Avg Cost	N	OP Total Cost
PTSD	$340	66,619	$22,641,177
Dxs Associated with PTSD	$313	7,543	$2,363,461
Dxs Associated with PTSD & non-associated Dxs	$369	9,486	$3,499,712
Else-PTSD dataset	$390	409	$159,309

Outpatient mTBI Costs

Table 9 shows all the 2007 and 2008 outpatient mTBI costs. The average cost of mTBI is $373 per incidence. During the two-year period, 7,712 patients were treated for mTBI and incurred a cost of $2.88 million. It is important to note that the lines of data that contained diagnoses associated with mTBI and diagnoses that are not associated with mTBI account for a huge medical cost. Based on the p-value, there is a statistical difference between the average cost of treating mTBI and the average cost of treating every other diagnosis not related to mTBI, see Appendix 6. The difference in costs is important because we are trying to prove the significance of the higher average cost of treating mTBI. Assuming the number of outpatient mTBI incidences are consistent throughout the war from 2003-2010, the DoD will incur a bill of $11.5 million for mTBI alone. Just like PTSD, there are also long-term implications and costs associated with mTBI, but we could not capture these costs using our dataset.

Table 9: mTBI Outpatient Average and Total Costs

Query	OP Avg Cost	N	OP Total Cost
mTBI	$373	7,712	$2,878,202
Dxs Associated with mTBI	$319	8,134	$2,592,992
Dxs Associated with mTBI & non-associated Dxs	$331	64,794	$21,459,946
Else-mTBI dataset	$354	3,417	$1,210,077

Outpatient PTSD and mTBI Costs

Table 10 explains the difference in average total cost when a person has PTSD, mTBI, or both combined. It is interesting to note the lower average cost for having both PTSD and mTBI. One reason for this could be the low number of people admitted to the outpatient clinic for PTSD and mTBI. Most mTBI cases require more than just a brief check-up. Table 10 shows there is a difference in the number of keys with PTSD and PTSD with mTBI as well as mTBI and mTBI with PTSD. In our query for mTBI there were 763 keys that also contained PTSD. In our query for PTSD, there were 763 keys that also contained mTBI, thus, we needed to pull queries for PTSD without mTBI and vice versa. If a patient is diagnosed with both PTSD and mTBI versus PTSD only, on average, it costs an additional $6.37 per incidence. We found it interesting that the average cost of a key containing mTBI and some PTSD codes was less than if the key only contained mTBI diagnoses. Here again, many patients with mTBIs will most likely incur bed days when seeking medical treatment. Table 10 supports this reasoning by the massive occurrences of PTSD compared to mTBI. Based on the p-value, there is a statistical difference between PTSD without mTBI and mTBI without PTSD. There is also a statistical difference between mTBI without PTSD and both PTSD and mTBI. However, we cannot reject the null hypothesis when comparing PTSD without mTBI and both PTSD and mTBI, reference Appendix D.

Table 10: 2007/2008 Outpatient PTSD and mTBI Average and Total Cost Differences

Query	OP Avg Cost	N	OP Total Cost
PTSD without mTBI	$340	66,619	$22,641,177
PTSD-may contain mTBI Dxs	$340	67,382	$22,901,662
Both	$346	763	$264,178
mTBI-may contain PTSD Dxs	$371	8,475	$3,148,269
mTBI without PTSD	$373	7,712	$2,878,202

Inpatient mTBI Costs

As mentioned in Chapter III, the inpatient data are much more costly than outpatient data because of bed days. Thus, the inpatient cost of PTSD and mTBI is thousands of dollars more than the outpatient costs.

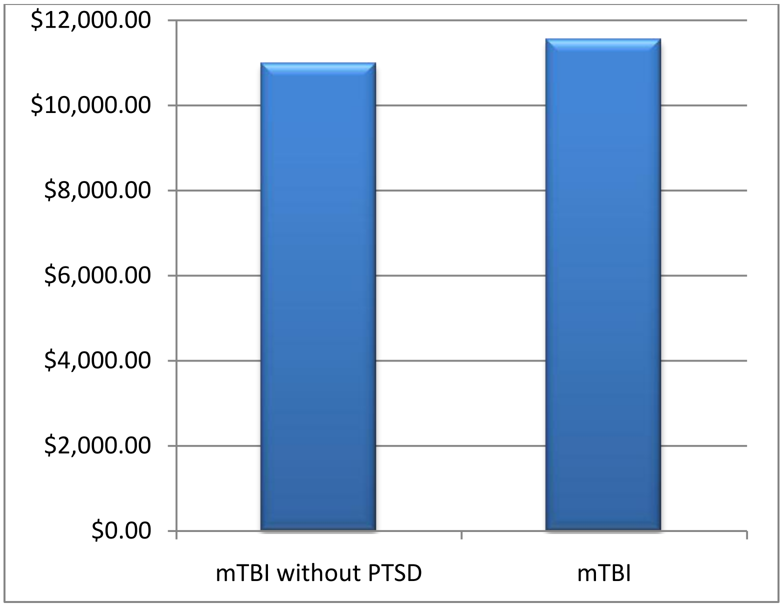

Figure 10: Average Cost of mTBI vs mTBI with PTSD

If a patient is diagnosed with mTBI without PTSD, on average, it will cost $10,983 to treat the patient, as shown in Figure 10. In 2007 and 2008, 94 patients were treated for mTBI only, resulting in a cost of just over $1 million. However, if the patient has PTSD, it will cost $560 more to treat the same patient. That is a 4.9% increase per incidence. While this increase may seem small, it is imperative to note that when we ran our queries, there were thirty-nine keys that contained PTSD when we pulled mTBI data. This results in an additional medical bill of $21,840 to properly care for these injured patients. However, based on the p-value, there is not a statistical difference between mTBI without PTSD and mTBI, see Appendix D. This may be because the costs were relatively similar.

Inpatient PTSD Costs

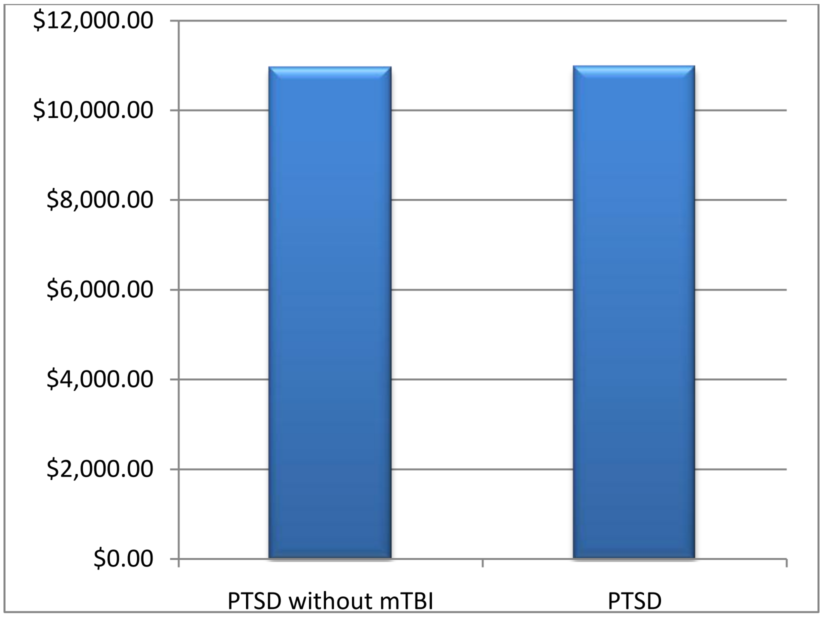

Figure 11: Average Cost of PTSD vs PTSD with mTBI

Figure 11 displays the cost difference of when a patient is diagnosed with PTSD without any mTBI diagnoses and when the patient has PTSD and some mTBI diagnoses. In 2007 and 2008, 3,031 patients were treated for PTSD only. This results in a cost of $33.2 million. However, if the patient has mTBI, it will cost $24 more to treat the same patient. It will cost $936 more to treat the thirty-nine patients diagnosed with PTSD when some of the same keys contain mTBI diagnoses. The cost difference depicted in Figure 11 is much less than in Figure 10, $536 per incidence to be exact. If a patient has mTBI with some PTSD diagnoses, it will cost $21,846 more to treat the patients than if they were diagnosed with PTSD and had some mTBI diagnoses. Contrary to our literature review, it is more expensive for the patient to be treated for mTBI, when the patient may have PTSD as well.

Inpatient PTSD and mTBI Costs

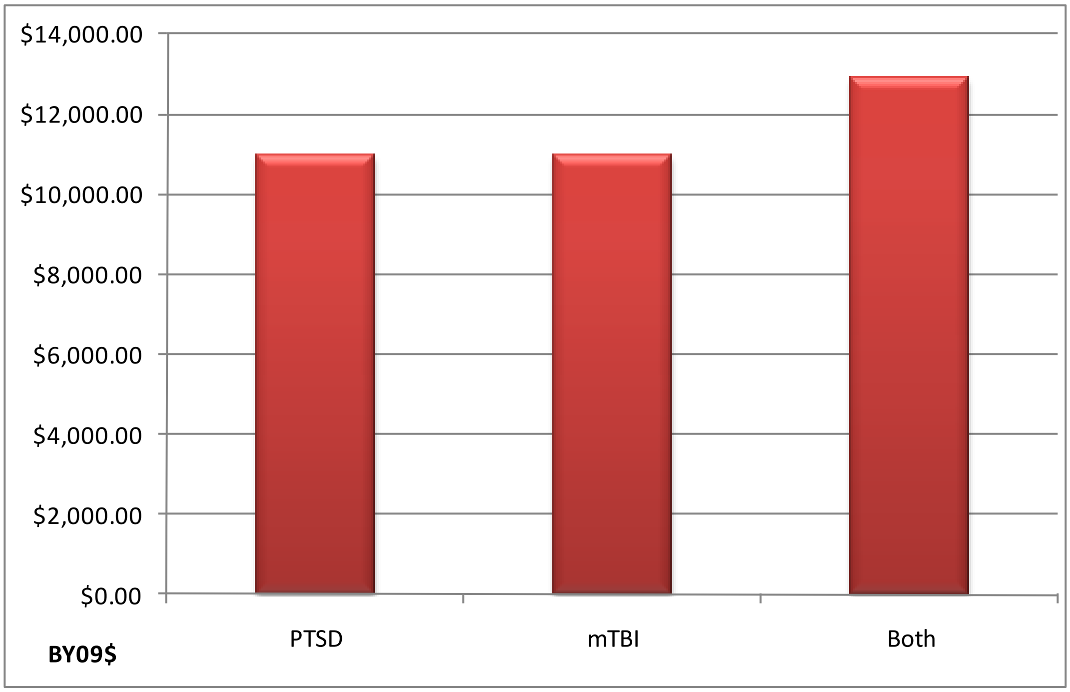

Figure 12: 2007/2008 Inpatient PTSD and mTBI Medical Costs

When we separate out PTSD and mTBI, we found that the average total cost is $10,946 and $10, 983, respectively. If a patient was diagnosed with both PTSD and mTBI the average total cost rose to $12, 893, as depicted in Figure 12. On average, when a person is diagnosed with both the cost increases $1,928 or 17.58% per incidence.

Cost Comparison

We built our model on mainly mTBI and PTSD diagnoses, which is not an accurate representation of a year's medical diagnoses. Everyday soldiers are diagnosed with illnesses unrelated to PTSD and mTBI, and our 2007 and 2008 mTBI and PTSD dataset do not account for these illnesses. Thus, we want to know if our costs are comparable to an entire year of military medical diagnoses.

Modeling Accuracy

The following section attempts to validate the costs demonstrated in the Methodology section. We offer a comparison by computing medical costs from a sample set of 2008 outpatient population data. The 2008 outpatient population data consisted of more than two million lines of data. We selected a sample set of the data to analyze and compare with our model. We also withheld ten percent of the 2008 outpatient population data to ensure we had a fair representation of the dataset.

2008 mTBI only and PTSD only Sample Set Comparison

As with the 2007 and 2008 outpatient data, we broke the 2008 sample set data out by mTBI, PTSD, and both. Table 11 represents the cost differences between the 2007/2008 outpatient data, the 2008 hold out data, and the 2008 sample set data. The three columns on the right are the costs for all incidences.

The 2008HO mTBI only column is $13 more per incidence whereas the 2008 mTBI only column is $80 less when compared to the 2007 and 2008 data. While the costs of the diagnoses associated with mTBI are relatively low, there are a large number of keys associated with mTBI causing the cost to be massive. The cost for diagnoses associated with PTSD work the same way. However, these costs are even bigger, reaching almost $53.5 million in the 2008 sample dataset. Keep in mind this is only two months of data for the 2008 and 2008 hold out dataset.

In both the columns with associated and non-associated diagnoses, the 2008 hold out shows these costs as being higher than the 2007/2008 dataset. This means that our queries tagged any key with mTBI and tagged any diagnoses associated with mTBI.

Then we ran another query and selected any of the diagnoses that are associated with mTBI but may not have mTBI.

Table 11: mTBI Only and PTSD Only Versus 2008 Population and Hold Out Data

Query	OP Avg Cost	2008HO	2008	OP Avg Cost*N	2008HO*N	2008*N
mTBI	$373	$386	$294	$2,878,202	$17,766	$528,430
Dxs Associated with mTBI	$319	$248	$190	$2,592,992	$3,758,027	$30,760,926
Dxs Associated with mTBI & non-associated Dxs	$331	$343	$203	$21,459,946	$6,263,257	$30,433,668
Else-mTBI dataset	$354	$306	$186	$1,210,077	$1,265,132	$4,600,095
PTSD	$340	$344	$345	$22,641,177	$342,212	$2,086,714
Dxs Associated with PTSD	$313	$265	$196	$2,363,461	$8,193,076	$53,464,051
Dxs Associated with PTSD & non-associated Dxs	$369	$388	$167	$3,499,712	$1,704,245	$8,927,764
Else-PTSD dataset	$390	$310	$121	$159,308	$398,624	$795,471

Another interesting finding is the else rows. These rows contain all keys not related to the illness of interest. In the 2007/2008 dataset, other diagnoses were more expensive than mTBI and PTSD. Whereas in the 2008 and 2008 hold out datasets, the cost of other diagnoses were relatively small compared to the mTBI and PTSD costs in the dataset.

We tested for statistical differences in the 2008 sample PTSD without mTBI and the 2008 hold out PTSD without mTBI and found no difference, which means the hold out is a good representation of the sample set. However, this was not the case for the 2008 sample mTBI without PTSD and the 2008 hold out mTBI without PTSD.

2008 Both mTBI and PTSD Sample Set Comparison

Table 12 shows the cost differences per case and total overall cost between the three datasets. The 2008 and 2008 hold out data for PTSD and PTSD keys that may contain mTBI cost more than these same diagnoses in the 2007/2008 dataset. However, there are not as many incidences in the 2008 and 2008 hold out dataset which results in a lower total cost. The mTBI results are different in that the 2008 dataset mTBI and mTBI keys that may contain PTSD are lower than the 2008 hold out and the 2007/2008 data. The 2008 hold out mTBI incidences cost more than the 2007/2008 mTBI incidences. Like the PTSD though, there are more incidences in the 2007/2008 dataset, which results in a higher total cost.

Table 12: Both PTSD and mTBI Versus 2008 Population and Hold Out Data

Query	OP Avg Cost	2008HO	2008	OP Avg Cost*N	2008HO*N	2008*N
PTSD	$340	$344	$345	$22,641,177	$342,212	$2,100,506
PTSD-may contain mTBI Dxs	$340	$344	$345	$22,901,662	$342,513	$2,115,319
Both	$346	$246	$274	$264,178	$246	$12,351
mTBI-may contain PTSD Dxs	$371	$384	$293	$3,148,269	$18,031	$541,004
mTBI	$373	$386	$294	$2,878,202	$17,766	$528,430

We tested for statistical differences in the 2008 sample both and the outpatient both and found the means are not the same. The mean for the outpatient both query and the mean mTBI query resulted in the means being statistically different, as seen in Appendix D.

When we combine PTSD and mTBI the costs should change. We predicted they will increase but that is not the case. The outpatient cost for PTSD and mTBI increased from only having PTSD but decreased from only having mTBI. The 2008 and 2008 hold out cost for having PTSD only or mTBI only decreased when a patient had both. It is important to note that there was only one incidence where a patient had both PTSD and mTBI in the 2008 hold out dataset represented in Table 12.

Based on our hypothesis and dataset findings, we believe PTSD is over diagnosed, and failing to diagnose and treat mTBI increases lifetime monetary costs over the money saved by treating a false positive mTBI. In order to determine if our hypothesis is accurate we looked at the average costs for treating patients with PTSD and any diagnoses associated to mTBI and compared these costs to the cost of treating both PTSD and mTBI. Figure 13 shows that, on average, it only costs $4 more for an outpatient procedure to treat a patient for both PTSD and mTBI. For the 2008 sample population and hold out datasets, it is cheaper to treat a patient with both PTSD and mTBI than to just treat them for PTSD when they also have diagnoses associated with mTBI. Unfortunately, this does not apply to the inpatient treatment costs, which leads us to our limitations.

Dataset	Treating PTSD w/ associated mTBI diagnoses	Treating both PTSD and mTBI
OP	$340	$346
IP	$9,458	$12,893
2008	$345	$274
Hold out	$344	$246

Figure 13: Cost Difference in Treating PTSD with Assocaiated mTBI vs Treating Both PTSD and mTBI

Limitations

Dataset

As with any dataset, there are limitations and our project is no exception. The first major limitation is that our medical cost data are not broken down by individual patient. Since we did not have individual data, we cannot break the data out by age, gender, rank, or mechanism of injury. In order to acquire individual patient data, one must process a research request through the Institutional Review Board (IRB). The IRB process is in place to protect the rights and welfare of human beings. We did not have the time to complete this process. Our dataset is by ordered diagnoses, which means, a patient can be included in more than one line of data or show up multiple times in the same line of data. Because the data are only gross financial data by clinic, we cannot compute costs per bed day. There are also zero cost diagnoses within the dataset. This means that the Current Procedural Terminology (CPT) codes used were zero weighted so there were no costs assigned but the encounter still occurred.

Another dataset limitation is that we are unable to control for all the other diagnoses that affect medical costs. We are focusing solely on PTSD and mTBI and this was the only data pulled from the Military Health System. Numerous diagnoses occur more frequently, such as tobacco use disorder, and cost more due to the massive number of occurrences. These types of diagnoses can skew our results and we cannot determine the effect they will have on our analysis. Thus, we focus on PTSD and mTBI costs. However, there are multiple diagnoses per line with only one cost. A patient may have PTSD, persistent insomnia, unspecified psychological circumstance, and alcohol abuse issues with only one cost for the line of data. We cannot break these costs out to show the cost of PTSD without the other diagnoses. This is the same case for mTBI diagnoses.

We originally received medical cost data with surgical and ICU costs. These numbers skewed the data drastically. While these factors are important, we chose to exclude them from our analysis. We also excluded a portion of the 2008 population dataset because there were no diagnoses associated with the medical costs. Since we could not attribute the costs to any diagnoses, we chose to exclude these costs.

The ICD-9 codes are the diagnosis codes listed in our dataset. While PTSD has a single code attached to the illness, mTBI does not. There are multiple diagnoses for the symptoms of mTBI and each patient can exhibit "a different mix of symptoms and the symptoms themselves are highly subjective in nature" (Arciniegas, Anderson, Topkoff, & McAllister, 2005). We based our selection of ICD-9 codes on the list used by Ommaya et al and the 2008 Invisible Wounds of War study Rand conducted. After determining which ICD-9 codes to use for mTBI we combined them which enabled us to compare PTSD and mTBI costs and properly analyze the data.

Another limitation is the military health system in general. The accounting system "does not measure the value of true outputs; does not capture all DOD health care costs; is inconsistent in how labor costs are allocated; and is difficult to compare direct care to private care and care among the services" (Task force on the Future of Military Health Care Final Report). It is difficult to portray actual PTSD and mTBI costs when they are not reported correctly, which is why the costs for PTSD, mTBI, and all the diagnoses associated and not associated with PTSD and mTBI looked the same in our findings.

We also have limitations with the number of keys in each query. Table 13 displays how many keys we obtained after running our queries mentioned in Chapter III. Each dataset contains a different number of keys. Since the inpatient dataset was small to begin with, our N ranges from two to 3,185. It is essential to note that in our 2008 hold out sample medical population data we only had one key with both PTSD and mTBI. This affected the significance test, since having only one or two data points leads to a sample variance that does not properly reflect the population variance. However, we had forty-five keys in the 2008 sample medical population data, which may lead to a better representation of the population variance.

Table 13: Number of Keys per Query per Dataset

Description of Query	2008	2008HO	OP	IP
PTSD only	6092	995	66619	3031
mTBI only	1800	46	7712	94
Both only	45	1	763	39
PTSD-may contain mTBI Dxs	6137	996	67382	3070
mTBI-may contain PTSD Dxs	1845	47	8475	133
Dxs Associated with PTSD	272524	30945	7543	190
Dxs Associated with mTBI	162095	15169	8134	188
Dxs Associated with both	27320	5681	39875	791
Dxs Associated with PTSD-may contain mTBI Dxs	274181	30989	13598	246
Dxs Associated with mTBI-may contain PTSD Dxs	172523	18192	61797	1598
Dxs Associated with PTSD & non-associated Dxs	53391	4393	9486	369
Dxs Associated with mTBI & non-associated Dxs	149963	18277	64794	3185
Dxs Associated with both PTSD & mTBI and non-associated Dxs	173611	19237	43419	2762
Dxs Associated with PTSD & non-associated Dxs--may contain mTBI Dxs	51857	4350	3077	276
Dxs Associated with mTBI & non-associated Dxs-may contain PTSD Dxs	141056	15706	13785	1861
Else-PTSD only dataset	6571	1287	409	2
Else-mTBI only dataset	24720	4128	3417	125
Else-Both only dataset	137602	12701		
Else-PTSD dataset	6403	1285		
Else-mTBI dataset	23154	3675		

Model

The 2008 outpatient population data contained numerous lines of data without diagnoses. Some of these lines had massive costs associated with them but our model was unable to account for them because they did not contain a diagnosis. Therefore, we excluded these lines from our model.

Illness Timelines

Timeframes are very important for mTBIs. Immediate treatment can prevent mTBIs from creating long-term medical issues. However, there are instances where a person may not realize they sustained a mTBI and may not seek medical treatment. Some symptoms may not even appear until weeks after the injury is sustained, so it is not uncommon for a mTBI to go undiagnosed or misdiagnosed. "It is also important to have rapid diagnosis and quickly implemented treatment of a TBI to prevent secondary injuries due to the chemical and physical changes to the brain that can accompany a TBI, swelling for example" (Adams, 2009). By missing the immediate treatment window, the recovery time may be prolonged, there is potential for serious personal complications and setbacks, and the cost, both personal and financial, will most likely increase. "A 1996 medical study showed that a behavior-related discharge from the military was 1.8 times more likely for a TBI patient than for a soldier without a TBI" (Adams, 2009). If the mTBI is undiagnosed, military mTBI patients "may be liable for tens of thousands of dollars' worth of medical bills, on top of lost wages (Adams, 2009).

Chapter Summary

In this chapter, we laid out the cost per incidence and total cost for PTSD only, mTBI only, PTSD and mTBI, mTBI keys that may contain PTSD, and PTSD keys that may contain mTBI. We found the inpatient costs are much higher than the outpatient costs but unfortunately because the diagnoses were not time ordered we could not calculate the cost of misdiagnosing PTSD and mTBI. Now that we analyzed the data, we continue our discussion of the results in the next chapter. We provide some recommendations for the decision makers and offer areas of further research.

Chapter V: Conclusions

In this chapter, we discuss our results and the limitations of our findings in an effort to guide further research in this area. In addition, we discuss how our findings can potentially result in policy implications.

Conclusions

PTSD and mTBI are the signature wounds of the current war and we determined the cost of each illness reported in 2007 and 2008. The two years of PTSD and mTBI data showed that 3,031 of the diagnosed people admitted to a military treatment facility had PTSD and 94 had mTBI, as shown in Table 14. The outpatient data showed a massive number of PTSD lines of data. While the number of lines of mTBI data in the outpatient dataset increased, the increase was not as pronounced as the increase in the number of PTSD lines. In the 2008 population sample and hold out datasets, the PTSD and mTBI illnesses were relatively small because these datasets included every medical diagnosis that occurred in 2008.

Table 14: Number of Lines of PTSD and mTBI in Each Dataset

Illness	IP Data	OP Data	2008 Sample	2008 Sample Hold Out
PTSD	3,031	66,619	6,092	995
mTBI	94	7,712	1,800	46
Both	39	763	45	1
Total lines of data	3,592	84,057	338,578	37,620

Table 15 displays the cost for incidence for PTSD, mTBI, and both combined. For the inpatient data, it costs more to have both PTSD and mTBI than to have each one individually. This is not the case for the 2008 Sample data and hold out data. Further analysis would need to be conducted to determine why the cost is less when a patient has both versus each one individually.

Table 15: Cost Per Incidence

Illness	Inpatient	Outpatient	2008 Sample Data	2008 Sample HO
PTSD	$10,946	$340	$345	$344
mTBI	$10,983	$373	$294	$386
Both	$12,893	$346	$274	$246

Table 16 displays the total cost for each illness of interest. The costs are much higher for the inpatient and outpatient illnesses but this is because the dataset was mainly PTSD and mTBI diagnoses for 2007 and 2008. It is important to note that there are long-term consequences associated with PTSD and mTBI and with only two years of data, we could not capture these long-term costs.

Table 16: Total Cost Per Illness

Illness	Inpatient	Outpatient	2008 Sample Data	2008 Sample HO
PTSD	$33,177,645	$22,641,177	$2,100,506	$342,212
mTBI	$1,032,444	$2,878,202	$528,430	$17,766
Both	$502,812	$264,178	$12,351	$246

The inpatient and outpatient costs are much larger than the 2008 sample data and hold out data. The 2008 sample dataset is only two months worth of 2008 outpatient data. In the population dataset, there are everyday occurrences of some ICD-9 codes.

Every military member is required to complete a PHA and consequently, the PHAs accounted for 2.54% of the dataset. Even though PTSD and mTBI only account for a small percentage of illnesses diagnosed in 2008, they are very serious illnesses.

Without proper diagnosis, these illnesses may cause irreversible damage and can lead to permanent symptoms. If a person incurs repeated mTBIs over an extended period (i.e., months, years) there is the potential for cumulative neurological and cognitive deficits. However, if a person incurs repeated mild TBIs within a short period (i.e., hours, days, or weeks) the results can be catastrophic or fatal (CDC). A person with an untreated mTBI or PTSD may be forced to live with permanent symptoms such as irritability, anxiety, and depression (Traumatic Brain Injury: The Journey Home). The National Institute of Neurological Disorders and Stroke noted that TBI can cause epilepsy and may increase the risk for Alzheimer's disease and Parkinson's disease as the person ages (Traumatic Brain Injury: Hope Through Research, 2002). With the increasing number of mTBIs being diagnosed, the future medical costs for treating the lasting effects could be massive. For example, over eight years, based on 2007 and 2008 PTSD and mTBI data, the DoD would hypothetically spend $132.7 million on inpatient treatment for PTSD and another $90.5 million in outpatient PTSD treatment costs for active duty alone. Following along with this example, mTBI inpatient costs could reach $4.1 million and outpatient costs could reach $11.5 million. With millions of dollars at stake for active duty personnel, we must also consider cost of treating veterans. We are currently experiencing the medical costs for the lasting effects of PTSD in the Vietnam War era and we believe the medical costs for mTBI could be worse. It is better to confront the lasting effects of mTBI before they get out of hand.

The Signature Wounds of War report by RAND mentions that from a societal perspective, within two years, evidence-based treatment will more than pay for itself for PTSD. The costs from the RAND model came from treatment expenditures, lost productivity, and costs associated with suicide. The cost savings come from enhanced productivity outcomes, lower risk of suicide, and less treatment episodes over the modeled time frame (Tanielian & Jaycox, 2008). Unfortunately, to date, there is no model for determining the cost savings for treating mTBI.

Future Research

Our research only focused on active duty medical costs. An extension of this research could be performed to account for National Guard or Air Reserve medical costs. Another great opportunity for future research would be to obtain IRB approval and examine patients based on medical diagnosis versus actual diagnosis. Diagnoses assigned chronologically could prove to be very useful in determining the cost of misdiagnosing PTSD and mTBI. With this information, a cost model could be constructed and help decision makers forecast the costs of PTSD and mTBI.

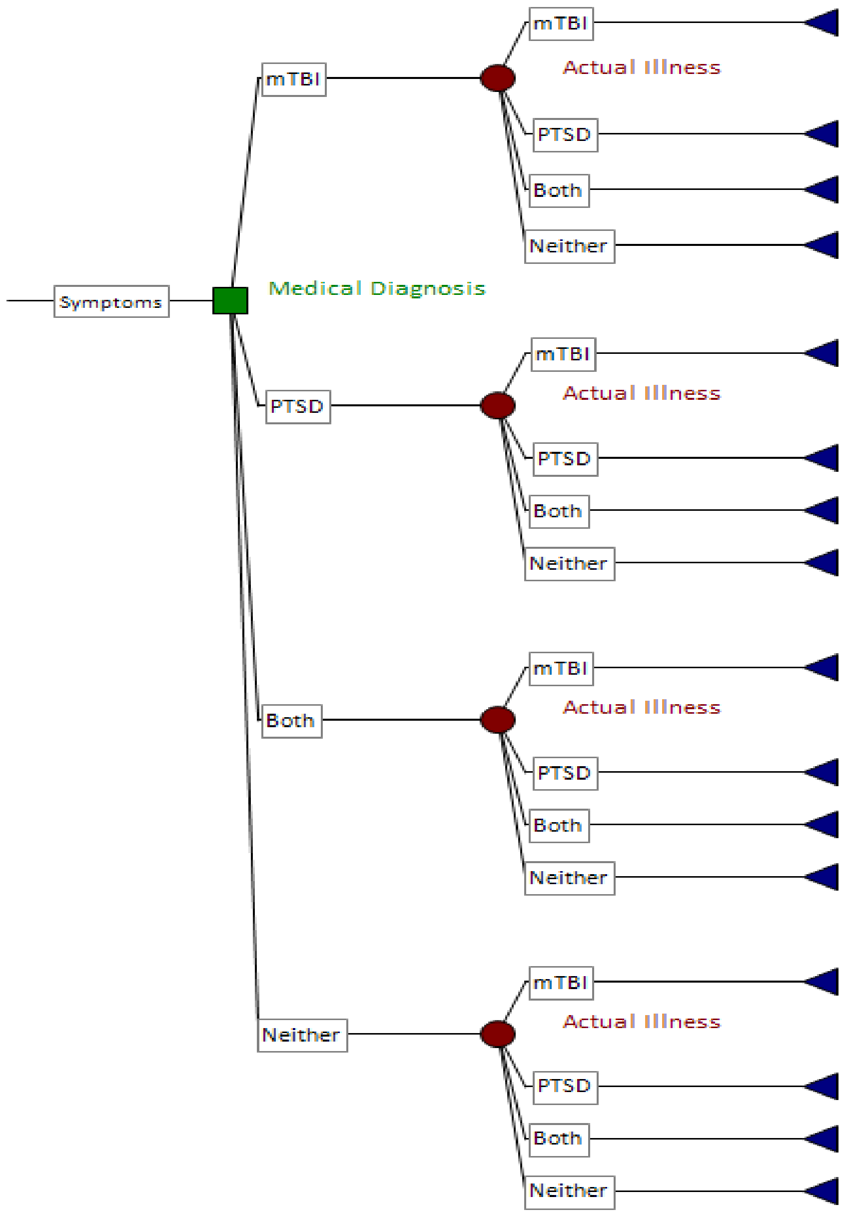

Figure 14: Decision Tree for Medical Diagnoses

Another area of research that we believe would be beneficial is to use patient data to build a decision tree, as represented in Figure 14. The decision tree could model the doctor's diagnosis decision and the cost for the decision as well as the chance that the diagnosis could be something else. Actual patient data could help determine if a patient was misdiagnosed with PTSD when they had mTBI and vice versa.

PTSD and mTBI are major medical issues that some soldiers are forced to deal with. These illnesses can cause more long-term medical issues if not properly treated in a timely manner. We owe it to our soldiers who are fighting for our freedom, to provide them with the proper medical care to give them a chance at a normal, healthy life.

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Appendix 1: Snapshot of Data Analysis

Key	PTSD	mTBI	Both	Sheet	Type	Holdout	FY	FM	Dx1	Dx2	Dx3	Dx4	Dx5	Dx6	Dx7	Dx8	ClinSalary	Lab	Other	OtherAncillary	OtherSalary	Pharmacy	Rad	TotalCost	Direct	Support	Encounters
1	4	4	3	FM5_6	OP	1	8	5	V589	81601	7962						$34.34	$17.88	$50.47	$0.74	$50.09	$70.03	$9.12	$232.66			1
2	4	3	2	FM5_6	OP	1	8	6	V589	8242							$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00			1
3	4	3	2	FM5_6	OP	1	8	5	V589	8441	72690						$13.43	$5.44	$66.35	$52.71	$28.99	$46.46	$9.66	$223.03			1
400361	4	5	4	OP07_08	OP	0	7	10	3102	3101	95901						$16.26	$10.77	$72.01	$6.20	$37.64	$62.57	$12.15	$217.60			1
400362	5	4	4	OP07_08	OP	0	7	10	3102	71946	30981						$12.53	$34.37	$100.06	$9.04	$56.17	$115.29	$47.46	$374.91			1
400363	5	4	3	OP07_08	OP	0	7	10	3102	7234	30740	30981					$30.41	$20.92	$45.79	$9.16	$58.69	$148.44	$36.12	$349.52			1
462929	3	5	3	IP07_08	IP	0	8	7	8600	8052	95901	94224	3051	3510	E993	E8498	$715.13	$263.85		$1,678.77	$9.47		$650.21	$6,108.92	$922.15	$1,869.33	1
462930	3	3	3	IP07_08	IP	0	8	7	8771	82030	8500	8761	8911	94128	94428	94800	$275.95	$327.71		$2,335.35	$143.98		$953.47	$8,506.48	$1,912.36	$2,557.67	1.0015
462931	4	4	3	IP07_08	IP	0	8	7	82330	8500	8760	9562	V4589	E9912			$498.89	$65.87		$2,511.12	$538.77		$238.36	$15,184.68	$2,028.20	$2,304.01	1.0015

Appendix B: mTBI Descriptions

Code	Description	Code	Description
80000	CLOSED SKULL VAULT FX	85109	CORTEX CONTUS-CONCUS NOS
80001	CL SKULL VLT FX W/O COMA	85181	BRAIN LACER NEC W/O COMA
80002	CL SKULL VLT FX-BRF COMA	85186	BRAIN LACER NEC-COMA NOS
80049	CL SKL VLT FX-CONCUS NOS	85200	TRAUM SUBARACHNOID HEM
80100	CLOS SKULL BASE FRACTURE	85201	SUBARACHNOID HEM-NO COMA
80101	CL SKUL BASE FX W/O COMA	85206	SUBARACH HEM-COMA NOS
80102	CL SKUL BASE FX-BRF COMA	85209	SUBARACH HEM-CONCUSSION
80106	CL SKUL BASE FX-COMA NOS	85300	TRAUMATIC BRAIN HEM NEC
80146	CL SKUL BASE FX-COMA NOS	85301	BRAIN HEM NEC W/O COMA
80196	OPN SKL BASE FX-COMA NOS	85400	BRAIN INJURY NEC
80300	CLOSE SKULL FRACTURE NEC	85401	BRAIN INJURY NEC-NO COMA
80301	CL SKULL FX NEC W/O COMA	85403	BRAIN INJ NEC-MOD COMA
80302	CL SKULL FX NEC-BRF COMA	85406	BRAIN INJ NEC-COMA NOS
80309	CL SKULL FX NEC-CONCUSS	85409	BRAIN INJ NEC-CONCUSSION
80400	CL SKUL FX W OTH BONE FX	8600	TRAUM PNEUMOTHORAX-CLOSE
8500	CONCUSSION W/OUT COMA	8604	TRAUM PNEUMOHEMOTHOR-CL
85011	CONCUSSION W/OUT LOC <30MIN	920	CONTUSION FACE/SCALP/NCK
85100	CEREBRAL CORTX CONTUSION	9584	TRAUMATIC SHOCK
85101	CORTEX CONTUSION-NO COMA	95901	HEAD INJURY, UNSPECIFIED
85102	CORTEX CONTUS-BRIEF COMA	95909	INJURY OF FACE AND NECK
85105	CORTEX CONTUS-DEEP COMA		

Appendix C: Query Results

PTSD without mTBI Results

PTSDonly	Sheet	Type	Holdout	N	ClinSalary	Lab	Other	therAncilla	OtherSalar	Pharmacy	Radiology	Direct	Support	TotalCost
2	FM5_6	OP	0	6571	$9.52	$7.45	$44.86	$16.17	$24.27	$12.27	$6.52			$121.06
2	FM5_6	OP	1	1287	$26.48	$23.18	$110.80	$43.00	$57.79	$28.39	$20.09			$309.73
2	IP07_08	IP	0	2	$76.90	$197.25		$1,302.60	$9.62		$292.08	$842.25	$897.29	$3,615.72
2	OP07_08	OP	0	409	$40.16	$20.12	$155.69	$223.36	$78.38	$41.72	$29.97			$389.51
3	FM5_6	OP	0	53391	$15.45	$9.86	$63.55	$65.18	$33.28	$13.01	$9.13			$167.21
3	FM5_6	OP	1	4393	$30.98	$29.58	$135.79	$61.40	$72.83	$48.34	$21.88			$387.95
3	IP07_08	IP	0	369	$525.79	$359.81		$3,007.84	$274.21		$712.12	$1,939.01	$2,211.63	$13,183.84
3	OP07_08	OP	0	9486	$35.72	$20.87	$141.24	$26.32	$78.87	$40.94	$30.15			$368.93
4	FM5_6	OP	0	272524	$16.53	$11.56	$75.65	$141.94	$46.41	$19.34	$10.74			$196.18
4	FM5_6	OP	1	30945	$22.67	$13.74	$101.62	$56.18	$74.96	$33.74	$9.48			$264.76
4	IP07_08	IP	0	190	$375.96	$225.44		$2,239.42	$139.65		$598.80	$1,690.54	$1,778.26	$8,998.50
4	OP07_08	OP	0	7543	$28.36	$18.42	$129.45	$31.88	$72.51	$15.98	$34.12			$313.33
5	FM5_6	OP	0	6092	$31.17	$8.14	$160.57	$15.20	$110.97	$25.38	$5.82			$344.80
5	FM5_6	OP	1	995	$36.55	$8.60	$152.70	$4.60	$111.77	$26.54	$5.74			$343.93
5	IP07_08	IP	0	3031	$664.95	$170.04		$1,142.69	$1,549.77		$120.89	$2,631.59	$3,822.17	$10,946.11
5	OP07_08	OP	0	66619	$32.06	$8.14	$155.77	$13.69	$110.54	$25.13	$5.47			$339.86

PTSD Results

PTSD	Sheet	Type	Holdout	N	ClinSalary	Lab	Other	therAncilla	OtherSalar	Pharmacy	Radiology	Direct	Support	TotalCost
2	FM5_6	OP	0	6403	$9.43	$7.38	$44.51	$16.10	$24.02	$12.22	$6.43			$120.09
2	FM5_6	OP	1	1285	$26.46	$23.17	$110.77	$42.95	$57.79	$28.39	$20.08			$309.61
3	FM5_6	OP	0	51857	$15.25	$9.74	$62.76	$22.73	$32.83	$12.82	$8.92			$165.05
3	FM5_6	OP	1	4350	$30.96	$29.68	$135.86	$49.02	$72.55	$48.22	$21.88			$388.16
3	IP07_08	IP	0	276	$588.45	$413.02		$3,379.42	$146.28		$797.75	$1,996.97	$2,140.23	$14,573.14
3	OP07_08	OP	0	3077	$36.33	$26.90	$150.02	$27.77	$87.48	$43.26	$40.13			$411.89
4	FM5_6	OP	0	274181	$16.54	$11.57	$75.70	$15.98	$46.44	$19.35	$10.76			$196.33
4	FM5_6	OP	1	30989	$22.67	$13.74	$101.63	$8.55	$74.96	$33.75	$9.49			$264.79
4	IP07_08	IP	0	246	$328.75	$207.34		$2,060.94	$180.58		$525.92	$1,538.81	$1,673.96	$8,356.27
4	OP07_08	OP	0	13598	$31.79	$18.85	$276.03	$17.12	$73.69	$26.18	$31.72			$334.24
5	FM5_6	OP	0	6137	$31.16	$8.14	$430.44	$2.75	$110.91	$25.37	$5.82			$344.68
5	FM5_6	OP	1	996	$36.55	$8.60	$63.05	$2.02	$111.76	$26.53	$5.74			$343.89
5	IP07_08	IP	0	3070	$663.78	$171.41		$1,119.76	$1,544.25		$128.07	$2,633.41	$3,823.42	$10,970.10
5	OP07_08	OP	0	67382	$32.07	$8.15	$155.76	$2.77	$110.48	$25.16	$5.50			$339.88

mTBI without PTSD Results

mTBIonly	Sheet	Type	Holdout	N	ClinSalary	Lab	Other	therAncilla	OtherSalar	Pharmacy	Radiology	Direct	Support	TotalCost
2	FM5_6	OP	0	24720	$14.67	$11.45	$68.51	$27.74	$36.91	$16.29	$10.53			$186.09
2	FM5_6	OP	1	4128	$26.51	$19.13	$115.29	$28.36	$72.13	$30.78	$14.28			$306.48
2	IP07_08	IP	0	125	$492.55	$142.60		$708.63	$745.20		$57.13	$2,337.58	$3,012.69	$7,972.66
2	OP07_08	OP	0	3417	$33.01	$7.72	$163.03	$2.05	$117.47	$26.09	$4.77			$354.13
3	FM5_6	OP	0	149963	$17.96	$10.92	$78.75	$21.80	$44.56	$18.49	$10.47			$202.94
3	FM5_6	OP	1	18277	$28.57	$19.33	$128.85	$17.17	$90.07	$45.79	$12.91			$342.69
3	IP07_08	IP	0	3185	$674.30	$193.87		$1,329.70	$1,486.28		$186.48	$2,620.32	$3,756.58	$11,514.68
3	OP07_08	OP	0	64794	$31.51	$8.46	$151.30	$3.28	$106.02	$24.58	$6.05			$331.20
4	FM5_6	OP	0	162095	$16.12	$11.10	$74.07	$12.33	$46.85	$19.12	$10.19			$189.77
4	FM5_6	OP	1	15169	$21.31	$12.32	$95.60	$5.03	$72.49	$32.43	$8.56			$247.74
4	IP07_08	IP	0	188	$257.90	$154.70		$1,836.79	$113.59		$504.37	$1,246.89	$1,423.88	$6,525.00
4	OP07_08	OP	0	8134	$28.50	$19.22	$130.31	$15.11	$74.32	$16.34	$34.99			$318.78
5	FM5_6	OP	0	1800	$29.08	$18.34	$109.51	$20.84	$63.90	$27.66	$24.24			$293.57
5	FM5_6	OP	1	46	$35.15	$22.15	$132.68	$6.81	$102.88	$63.22	$23.34			$386.23
5	IP07_08	IP	0	94	$361.87	$297.17		$2,427.23	$327.20		$527.78	$1,711.81	$1,972.95	$10,983.45
5	OP07_08	OP	0	7712	$37.16	$20.49	$143.34	$22.28	$76.60	$43.63	$29.71			$373.21

mTBI Results

mTBI	Sheet	Type	Holdout	N	ClinSalary	Lab	Other	therAncilla	OtherSalar	Pharmacy	Radiology	Direct	Support	TotalCost
2	FM5_6	OP	0	23154	$13.90	$11.42	$64.40	$27.67	$33.48	$15.66	$10.59			$177.14
2	FM5_6	OP	1	3675	$26.60	$21.06	$114.43	$31.97	$67.37	$32.12	$15.90			$309.45
3	FM5_6	OP	0	141056	$17.52	$11.19	$75.21	$23.67	$40.88	$18.36	$10.87			$197.69
3	FM5_6	OP	1	15706	$27.70	$22.22	$129.02	$20.91	$87.21	$50.73	$14.84			$352.63
3	IP07_08	IP	0	1861	$753.62	$238.85		$1,684.87	$1,382.84		$236.38	$2,751.11	$3,789.02	$12,792.70
3	OP07_08	OP	0	13785	$34.14	$10.58	$149.51	$8.32	$96.98	$30.04	$9.01			$338.59
4	FM5_6	OP	0	172523	$16.37	$11.06	$75.56	$12.43	$48.03	$19.21	$10.11			$192.77
4	FM5_6	OP	1	18192	$21.88	$12.10	$97.74	$5.26	$74.39	$31.90	$8.39			$251.66
4	IP07_08	IP	0	1598	$523.39	$132.38		$901.15	$1,374.75		$140.18	$2,290.25	$3,377.19	$9,132.95
4	OP07_08	OP	0	61797	$31.75	$8.61	$154.80	$3.12	$109.32	$24.39	$6.87			$338.88
5	FM5_6	OP	0	1845	$29.05	$18.12	$109.83	$20.58	$64.18	$27.49	$23.98			$293.23
5	FM5_6	OP	1	47	$34.89	$21.88	$132.58	$6.69	$102.53	$62.16	$22.92			$383.64
5	IP07_08	IP	0	133	$422.96	$292.49		$2,416.31	$554.58		$579.36	$2,024.86	$2,545.25	$11,543.61
5	OP07_08	OP	0	8475	$37.28	$19.95	$143.78	$21.40	$77.27	$42.98	$28.81			$371.48

Both PTSD and mTBI Results

Both	Sheet	Type	Holdout	N	ClinSalary	Lab	Other	therAncilla	OtherSalar	Pharmacy	Radiology	Direct	Support	TotalCost
2	FM5_6	OP	0	137602	$15.75	$11.89	$67.81	$18.34	$40.66	$17.41	$10.53			$182.39
2	FM5_6	OP	1	12701	$22.71	$21.19	$106.85	$19.74	$68.86	$36.14	$15.46			$290.95
3	FM5_6	OP	0	173611	$17.90	$11.41	$87.23	$18.98	$49.30	$21.33	$11.44			$217.60
3	FM5_6	OP	1	19237	$24.74	$16.48	$110.74	$10.02	$77.96	$54.84	$11.62			$306.41
3	IP07_08	IP	0	2762	$684.93	$213.54		$1,544.51	$1,377.28		$234.13	$2,588.19	$3,648.45	$11,909.31
3	OP07_08	OP	0	43419	$32.93	$13.32	$142.59	$10.40	$92.17	$32.11	$13.88			$337.40
4	FM5_6	OP	0	27320	$15.85	$9.42	$77.60	$9.95	$50.85	$19.17	$9.06			$191.91
4	FM5_6	OP	1	5681	$22.99	$7.35	$97.35	$2.54	$78.90	$24.02	$4.62			$237.77
4	IP07_08	IP	0	791	$485.76	$120.26		$701.61	$1,272.47		$90.17	$2,267.23	$3,246.57	$8,352.55
4	OP07_08	OP	0	39875	$31.91	$8.32	$156.38	$2.85	$110.50	$24.06	$6.62			$340.65
5	FM5_6	OP	0	45	$26.92	$6.42	$127.31	$6.62	$79.18	$18.11	$9.92			$274.48
5	FM5_6	OP	1	1	$20.98	$7.23	$127.57	$0.05	$84.01	$5.80	$0.67			$246.31
5	IP07_08	IP	0	39	$570.08	$281.21		$2,390.02	$1,102.16		$703.59	$2,778.78	$3,923.50	$12,892.61
5	OP07_08	OP	0	763	$38.96	$12.08	$150.16	$8.64	$87.16	$33.49	$15.75			$346.24

Appendix D: Statistical Difference in Queries

Means	vs Means	z- value	p-value
Outpatient PTSD without mTBI	Outpatient mTBI without PTSD	-12.4319	
Outpatient mTBI without PTSD	Outpatient Everything Else	3.7163	0.9999
Outpatient PTSD without mTBI	Outpatient Everything Else	-5.1361	
Outpatient mTBI without PTSD	Outpatient Everything Else	3.7163	0.9999
Outpatient PTSD without mTBI	Outpatient Both PTSD and mTBI	-0.7403	0.22965
Outpatient mTBI without PTSD	Outpatient Both PTSD and mTBI	3.0155	0.99874
Inpatient mTBI without PTSD	Inpatient Both PTSD and mTBI	-0.6015	0.2451
Outpatient Both	Outpatient mTBI	-3.0155	0.00126
Inpatient mTBI	Inpatient mTBI without PTSD	0.2625	0.60257
Inpatient mTBI without PTSD	Inpatient Everything Else	1.6951	0.95543
2008 Sample PTSD without mTBI	Outpatient PTSD without mTBI	1.6742	0.95254
2008 Sample mTBI without PTSD	Outpatient mTBI without PTSD	-10.6751	
2008 Sample PTSD without mTBI	2008 Sample mTBI without PTSD	6.7757	
2008 Sample mTBI without PTSD	2008HO mTBI without PTSD	-1.7570	0.0392
2008 Sample PTSD without mTBI	2008HO PTSD without mTBI	0.1087	0.5438
2008 Sample Both	Outpatient Both	-2.1998	0.01101

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14. ABSTRACT

Mild Traumatic Brain Injuries (mTBIs) and Post Traumatic Stress Disorder (PTSD) are two of the signature wounds of war. Due to the advances in technology the survival rates are higher than in previous wars, however, the weaponry has changed. The world has seen an increase in the use of suicide bombs, improvised explosive devices and rocket propelled grenades which increases the number of blast related injuries. One of the major problems with blast related injuries is that they can be invisible to the naked eye. The lack of physical evidence suggests the soldier is not injured and can be sent back into battle, when there could be an undetected internal injury.

Due to the overlap in symptoms, many soldiers are being treated for PTSD instead of mTBI, which can cause long-term damage. In order to shed light on this issue, this thesis evaluates 2007-2008 active duty medical costs to determine the costs the PTSD and mTBI. The findings suggest that mTBI and PTSD account for .53% and 1.8%, respectively, of the 2008 population data sample. While this may seem like a small percentage this was only two months of data. However, it is important to properly diagnose mTBI and PTSD because these illnesses could cost the military member thousands of dollars in out of pocket medical costs.

15. SUBJECT TERMS
Mild Traumatic Brain Injury, Posttraumatic Stress Disorder, Costs

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