Invisible Wounds of War

Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery

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CHAPTER SIX

The Cost of Post-Deployment Mental Health and Cognitive Conditions

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Introduction

The previous part of this monograph (see Part III) described the consequences associated with deployment-related post-traumatic stress disorder (PTSD), major depression, and traumatic brain injury (TBI). In this chapter, we evaluate the costs associated with these conditions. Prior analyses of the costs associated with the conflicts in Afghanistan and Iraq have typically used standard accounting methodologies to project the costs that accrue to the government (Bilmes, 2007; Bilmes and Stiglitz, 2006; Goldberg, 2007), typically taking a per-person cost figure from existing data, multiplying by the projected population, and inflating over time with trend factors. These studies have focused on the total cost of the conflicts, with medical costs as one component (Bilmes and Stiglitz, 2006; Wallsten and Kosec, 2005), or specifically on the medical and disability costs (Goldberg, 2007; Bilmes, 2007). In our analysis, we focus on a narrower spectrum of conditions—costs related to TBI, PTSD, and major depression. However, we consider a wide array of consequences, including the costs related to mental health treatment, the costs of suicide, and costs stemming from reduced productivity. Moreover, we take a societal perspective and consider costs that accrue to all members of U.S. society, which potentially include not only government agencies (e.g., the Departments of Defense [DoD] and Veterans Affairs [VA]), but also servicemembers, their families, employers, private health insurers, taxpayers, and others.

Prior cost studies have considered three perspectives: the societal perspective, the government perspective, and the VA perspective. Gold (1996) recommends that all cost analyses consider the societal perspective, because this is the only approach that never counts a cost to one member of society as a benefit or savings to another (as would be the case, for example, if a charitable organization rather than the VA paid for mental health treatment for some returning veterans). However, at times, policymakers may be concerned only with costs that accrue to the government or to specific government agencies, such as the VA. In our analysis, we consider the U.S. societal perspective because we believe that the cost of treating servicemembers injured in Afghanistan or

Iraq is a national responsibility and that we as a society should be committed to minimizing all costs, regardless of whether they accrue to government agencies, military servicemembers, their families, taxpayers, or others.

We use several approaches to estimate costs related to mental health and cognitive injuries. For PTSD and major depression, we use a microsimulation model to project current-year costs as well as costs incurred in the future. Unlike standard accounting methods, a microsimulation model takes a hypothetical group of simulated individuals and predicts future cost-related events, allowing the simulated population to experience mental conditions, mental health treatment, and secondary outcomes, such as employment. An advantage of the microsimulation approach is that it treats mental disorders as chronic conditions, allowing for both remission and relapse over time. In addition, the microsimulation model can be useful for evaluating different policy scenarios. In our case, we are particularly interested in asking the policy question: "If we increase the use of evidence-based treatment, will we save money in the long run?" This type of question would be difficult to evaluate in a standard accounting framework, because standard accounting models are based on average expenditures for a population and do not allow different individuals to experience different treatments, subsequent outcomes, and costs.

A challenge for building a microsimulation model is the availability of information to estimate key parameters, such as the probability of developing a mental health condition, the probability of getting treatment depending on having a condition, and the probability of experiencing secondary outcomes, such as unemployment. Because these parameters must come from either published literature or secondary data analysis, the literature and available data must be relatively well developed to ensure that the probabilities used in the model are credible. In our literature review to examine the consequences of a mental health condition (see Chapter Five), we found that, while the literature on PTSD and major depression is reasonably well developed (although, at points, it is thin), the literature on TBI is much less comprehensive. As a result, we could not include TBI in our microsimulation model, and we instead calculated the costs of TBI using a prevalence-based cost-of-illness approach. While the cost-of-illness approach enables us to predict costs associated with TBI in a particular year (in this case, 2005), we could not use this methodology to evaluate policy changes, such as an increase in evidence-based treatment. Moreover, because of differences in time frame and methodology, the estimates from the cost-of-illness approach for TBI are not directly comparable with those for PTSD and major depression. However, in the absence of more-complete data, we believe that the cost-of-illness approach provided useful information about the total and per-case cost of deployment-related TBI in a given year.

The main cost outcomes that we consider in our analysis include treatment costs, the costs of lives lost to suicide, costs related to lost productivity (including reduced employment and lower earnings), and costs associated with TBI-related death. Many other secondary costs are likely to be related to PTSD, major depression, and TBI, such as costs stemming from family stress, caregiver burden, homelessness, and substance abuse co-morbidity. We do not incorporate these effects into our cost estimates for several reasons, including sparse literature, uncertainty about whether a mental health condition causes the problem (as opposed to simply being correlated with the problem), and difficulty assigning a dollar figure to intangible outcomes, such as family well-being. To the extent that these omitted costs are caused by psychological and cognitive injuries, our cost figures should be considered lower-bound estimates of the true costs. While a limitation of our study is that we cannot address all costs associated with mental health and cognitive conditions, we nevertheless think this analysis provides valuable information in that it presents what can be thought of as a lower-bound estimate of societal costs.

Our microsimulation model predicts that two-year costs resulting from PTSD and major depression for the approximately 1.6 million individuals who have deployed since 2001 could range from $4.0 to $6.2 billion, depending on how we account for the costs of lives lost to suicide. Because this calculation includes costs for servicemembers who returned from deployment starting as early as 2001, many of these two-year costs have already been incurred. However, if servicemembers continue to be deployed in the future, expected costs will increase beyond the range discussed in this chapter. Providing evidence-based treatment to everyone in need could reduce these costs by as much as 27 percent. The cost savings associated with evidence-based treatment are clear for major depression and less robust for PTSD or co-morbid PTSD and major depression. The instability of the results for PTSD stems from the fact that the research base on effective treatments is still growing (Institute of Medicine, 2007; discussed in Chapter Seven), as well as from limited information on potential reductions in productivity stemming from PTSD. Our cost-of-illness estimates indicate that the cost of deployment-related TBI ranged from $90.6 to $135.4 million in 2005 ($96.6 to $144.4 million at 2007 price levels). When applying the per-case cost in 2005 to the total number of TBI cases identified (2,726),[1] we estimated the total cost of deployment-related TBI to be between $591 and $910 million (2007 dollars). Again, many of these costs have already been incurred, given that the figures account for all cases of TBI identified since September 2001. For all three conditions, costs related to reduced productivity accounted for a large share of total costs.

The remainder of this chapter is organized into four sections. First, we provide an overview of the previous literature on medical costs related to deployment. Second, we discuss the PTSD and major depression simulation model and ask whether society could save money by investing more in evidence-based treatment for these conditions. Third, we present the cost analysis for traumatic brain injury. Finally, we offer overall

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1 The total number of cases is taken from *Serve, Support, Simplify* (President's Commission on Care for America's Returning Wounded Warriors, 2007, p. 2).

conclusions about the societal costs of deployment-related mental health and cognitive conditions.

Prior Cost Estimates

Several prior studies have projected the medical costs associated with the wars in Afghanistan and Iraq (Bilmes, 2007; Goldberg, 2007; Bilmes and Stiglitz, 2006; Wallsten and Kosec, 2005). While some studies estimate the overall cost of the war, with medical care as one component (Bilmes and Stiglitz, 2006; Wallsten and Kosec, 2005), others have focused specifically on the medical costs associated with deployment to Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) (Bilmes, 2007; Goldberg, 2007). In general, these studies have used a standard accounting framework to project these costs. This methodology typically involves taking an average cost per veteran for each cost component (e.g., injuries, fatalities), multiplying this cost by the expected number of veterans, and applying trend factors to inflate these costs over time. While some studies have estimated separate costs for TBI, other medical costs in these studies have been measured at a very aggregate level, such as average cost per patient regardless of condition, and cannot easily be disaggregated to estimate costs for particular illnesses.

Although the studies use similar methods, they differ in important ways. For example, some have focused on the costs that accrue to the federal government (Bilmes, 2007; Goldberg, 2007), while others have taken a societal perspective and included costs such as the loss in future productivity from injury-related disability (Bilmes and Stiglitz, 2006; Wallsten and Kosec, 2005). In addition, some include costs from Afghanistan and Iraq (Bilmes, 2007), while others focus solely on Iraq (Wallsten and Kosec, 2005; Bilmes and Stiglitz, 2006; Goldberg, 2007). While most studies have focused specifically on costs accruing to either the U.S. government or U.S. society at large, Wallston and Kosec (2005) consider costs to other countries as well. Moreover, each study includes a somewhat different set of costs. Given these differences, the estimates from these studies can be difficult to compare. Table 6.1 summarizes the perspectives and cost components included in several recent studies.

The first estimate of the medical costs of the war in Iraq was generated by Wallsten and Kosec (2005). This study took a societal perspective and estimated the lifetime costs associated with lives lost ($14 billion) and injuries incurred ($18.2 billion) between March 20, 2003, and August 25, 2005, to be $32.2 billion. A primary limitation of this estimate is that it does not include any costs associated with deployment-related mental health problems and thus may understate the true medical costs.

Bilmes and Stiglitz (2006) generate an estimate of the governmental costs of the war in Iraq through 2015 of between $700 billion and $1.2 trillion. In their conservative estimate (i.e., $700 billion), VA costs are estimated to be $40 billion, the cost of brain injuries $14 billion, and the cost of veterans disability payments $37 billion. Unfortunately, the VA cost estimate is at a very aggregate level; therefore, we are unable

Table 6.1
Studies of the Cost of the Wars in Afghanistan and Iraq

Study	Perspective(s) Considered	Goal of Study	Cost Categories Included
Our report	Societal (within the United States)	To project 2-year post-deployment costs associated with PTSD and depression; to calculate total costs associated with TBI in 2005	Treatment and rehabilitation costs for PTSD, depression, and TBI Medical costs associated with suicide attempts and completions Value of lives lost to suicide Value of lives lost to TBI Lost productivity stemming from PTSD, TBI, and depression
Bilmes and Stiglitz (2006)	Governmental and societal (within the United States)	To project total governmental and societal costs of the Iraq war through 2015	Governmental costs Money spent to date Future spending on operations VA costs Cost for brain injuries Veterans disability payments Demobilization costs Increased defense spending Interest on the debt Societal costs Governmental costs minus veterans disability pay Cost of Reserve personnel Cost of fatalities Loss due to brain injuries Loss due to other injuries Depreciation of military hardware
Bilmes (2007)	VA	To project long-term costs to the VA	Disability compensation Medical costs
Goldberg (2007)	VA	To project 10-year costs to the VA	Medical costs Disability compensation Dependency and indemnity compensation
Wallsten and Kosec (2005)	Societal, including non-U.S. societies	To project costs and benefits of the war in Iraq through 2015	Military and government expenditures Fatalities Injuries, including TBI Lost wages of Reserve personnel Avoided costs, such as avoided murders by Saddam Hussein

to separate from the total the costs associated with treating deployment-related mental health conditions. To provide another perspective, Bilmes and Stiglitz (2006) make several adjustments to the estimate of governmental costs to provide an estimate of the societal costs of the war. Their societal estimate accounts for additional costs that accrue to parties other than the federal government, such as the loss in productivity associated with injury-related disabilities or premature death. Including such costs adds another $105 to $167 billion to the total cost estimates.

In a recent study, Bilmes (2007) expands on her prior work (Bilmes and Stiglitz, 2006) to generate a more detailed estimate of the lifetime costs of veterans' medical care and disability payments. She estimates projected VA medical costs to be between $208 and $600 billion. Again, the medical cost estimate is at an aggregate level and does not allow us to separate out the costs of specific conditions, such as PTSD, major depression, or TBI. Disability payments are projected to be between $68 and $127 billion.

In recent testimony before the U.S. House of Representatives Committee on Veterans' Affairs, the Deputy Assistant Director for National Security at the Congressional Budget Office (CBO), Matthew S. Goldberg, presented projections on the VA costs of care for OEF/OIF veterans (Goldberg, 2007). The CBO estimates that VA medical costs associated with OEF/OIF veterans are between $7 and $9 billion over the period 2008 through 2017. Disability and survivor benefits are estimated to contribute an additional $3 to $4 billion over the same time period. In the testimony, the CBO argues that the medical cost estimates generated by Wallsten and Kosec (2005) and Bilmes and Stiglitz (2006) are too high, largely stemming from the assumptions they make regarding the number and severity of TBI cases and overall service utilization among OEF/OIF veterans.

There are a number of similarities and differences between the methodology used in this report and those employed in prior studies. For example, like Wallsten and Kosec (2005), we take a societal perspective and consider costs that accrue to all potential payers, including the government, individuals, employers, and private health insurers. However, unlike Wallsten and Kosec, we focus our examination of societal costs on those costs incurred by the United States and its citizens and consider costs over a much shorter time frame. The basic method we use to generate the estimated cost of TBI is quite similar to that used in prior studies; however, for PTSD and major depression, we use a microsimulation model to generate our cost estimates. With the microsimulation model, we follow each modeled individual over time, accounting for the effects of a mental health condition and treatment trajectories on productivity and suicide. We can then model alternative policy scenarios, such as an increase in the fraction of veterans receiving evidence-based treatment, and reevaluate costs after accounting for such changes. Standard accounting methodologies, in contrast, typically project future costs in a relatively stable policy environment.

The prior estimates have focused on a comprehensive or nearly comprehensive array of medical care cost components; we limit our analysis to costs stemming specifically from TBI, PTSD, and major depression. We include costs related to treatment, mortality, productivity, and suicide. These are appropriately considered societal costs because they represent new expenditures or losses that would not have been incurred, or that could have been used for other purposes, in the absence of combat-related mental health injuries. None of the prior studies has accounted for the costs associated with suicide. At the same time, we omit some costs that have been included in prior studies. For example, we do not include disability payments in our calculations because they are intended to replace lost wages, which are already included in our model.

Finally, the time frame for our analyses is different from that of prior studies. Our microsimulation model for PTSD and major depression focuses on a two-year time horizon, and our TBI estimate is for a single year, whereas previous estimates have projected costs over a much longer time frame—ten years (Goldberg, 2007; Bilmes and Stiglitz, 2006) or a lifetime (Bilmes, 2007; Wallsten and Kosec, 2005). We limit our model time horizon to two years because we do not have enough information to break down costs by type of service or to parameterize the course of remission and relapse from mental health conditions over a longer time frame. Although several studies (Angst, 1986; Judd et al., 1998; Judd et al., 2000; Kennedy, Abbott, and Paykel, 2004) have traced the course of depression for ten years or more, these publications do not report sufficient information to model the timing of transitions between relapse and remission. To our knowledge, no studies analyze long-term relapse and remission rates for PTSD. Other studies of the medical costs of the conflicts in Afghanistan and Iraq have been able to analyze a longer time frame because they have explored average costs per patient across a wide range of conditions and projected this number over time, adjusting for expected number of patients, inflation, and other factors. While some of these studies have generated long-term costs for TBI, they have used an aggregate estimate (i.e., total costs not broken down across different types of services or levels of injury severity) of the lifetime treatment costs of TBI (Wallsten and Kosec, 2005). Because the focus of these studies is broad and the costs of TBI are only one component of the total, the lack of detail in the lifetime cost estimate is not a concern. However, for this monograph, we focus specifically on the costs of major depression, PTSD, and TBI, and we consider the costs associated with different types of treatment and different degrees of severity and co-morbidity, allowing—in the simulation model—remission and relapse rates to be influenced by treatment type.

The Cost of PTSD and Major Depression and the Benefits of Evidence-Based Care

Background

Many veterans return from deployment with a mental health condition or the likelihood of developing a mental health condition. Chapter Three concludes that probable rates of PTSD in returning veterans range from 5 to 15 percent and that probable rates of major depression range from 2 to 10 percent. Our survey of returning servicemembers and veterans (Chapter Four) found similar results, with 13.8 percent of all previously deployed troops meeting screening criteria for PTSD and 13.7 percent meeting screening criteria for major depression. Hoge et al., (2004) found that less than half of returning soldiers and marines with a probable mental health condition received any care within three to four months after returning from Iraq or Afghanistan; an even smaller number received evidence-based care. The evidence suggests that increasing the percentage of veterans who receive care would improve health outcomes and that increasing the percentage of veterans who receive evidence-based care would lead to even greater improvements.

Although the treatment costs could be substantial in the short term, providing evidence-based care to all returning veterans with a mental health condition may in fact be a cost-saving strategy when viewed over the longer term. The societal costs of forgone care or inadequate care can also be substantial: They include treatment costs for relapses and lost productivity. Conversely, positive outcomes associated with effective treatment can lead to improved productivity, health, and quality of life. Thus, any calculation of post-deployment mental health treatment costs needs to include potentially offsetting savings that follow from improving mental health outcomes among veterans. In this section, we present the results of a microsimulation model to estimate these costs. Our model predicts two-year costs associated with three care alternatives for veterans returning to the states with post-traumatic stress disorder or major depression: usual care, evidence-based care, or no care.

Motivation for the Microsimulation Approach

Both major depression and PTSD are likely to be costly to society, not only because treatments are expensive but also because these illnesses are associated with significant reductions in productivity. Studies of the civilian population have found that lost productivity associated with a mental health condition represents a significant cost to society and to employers (Ettner, Frank, and Kessler, 1997; Kessler, Borges, and Walters, 1999; Druss, Rosenheck, and Sledge, 2000), with one study reporting that workers with depression cost employers as much as $44 billion a year (Stewart et al., 2003). Studies of veterans with PTSD have similarly found that these individuals have a lower probability of working (Zatzick et al., 1997; Smith, Schnurr, and Rosenheck, 2005), higher missed days at work conditional on working (Hoge et al., 2007), reduced productivity—known as "presenteesim"—while at work (Stewart et al., 2003), and lower earnings (Savoca and Rosenheck, 2000) than peers without a mental health condition. In addition, there may be significant costs stemming from the downstream consequences of these illnesses, including increased non–mental health related medical costs, caregiver burden, strain on family relationships, domestic violence, substance abuse, crime, and homelessness (Dekel and Solomon, 2006; Brooks, 1991; Liss and Willer, 1990; Kozloff, 1987; Solomon et al., 1992; Calhoun and Beckham, 2002; Kulka et al., 1990; Ommaya et al., 1996; Rosenheck and Fontana, 1994).

We used a microsimulation model to estimate the costs and benefits associated with three courses of treatment that may be provided to military servicemembers returning home with major depression, PTSD, or both conditions. Our model took a representative cohort of individuals returning from OEF and OIF and mapped their trajectories over a period of two years, taking into account treatments received and events that may occur as a result of a mental health condition.[2] The treatment pathways that we considered in our model are

- usual care
- evidence-based care
- no care.

We estimated the costs associated with PTSD and major depression among post-deployed servicemembers from prevalence rates found in prior literature. However, it is not clear that all of these costs are causally attributable to the conflicts in Afghanistan and Iraq. While deployment likely increases the chance that a servicemember develops PTSD or major depression, some servicemembers would have developed these conditions even without deployment. As a result, our analysis focused on the full costs associated with mental health conditions among the post-deployed population, rather than the incremental costs attributable to deployment in Afghanistan or Iraq. Nevertheless, understanding the costs of these conditions, and the potential reduction in costs associated with evidence-based care, is valuable because the nation has obligated itself to providing health care for all returning servicemembers, regardless of where their injuries were sustained.

Events addressed in the model include labor market outcomes (retention within DoD, career progression within the military conditional on retention, employment in the civilian sector, and civilian earnings), suicide attempts, and suicide completions. Although we do not currently model other cost categories, such as costs related to domestic violence, homelessness, or substance abuse, the model could be expanded to incorporate these costs if adequate data were available. The model estimates both the total costs of illness and the societal costs associated with forgone or inadequate care.

Note that the estimates presented here are necessarily imprecise. The data on which to base model parameters are thin, and thus there are often a number of assumptions that must be made to generate important model parameters. Because of this uncertainty, we developed three cost projections: a baseline scenario, a low-cost scenario, and a high-cost scenario.

Overview of the Microsimulation Framework

The simulation model develops a two-year life-course projection for a group of 25-year-old military servicemembers returning from OEF/OIF at a rank of E-5 with 5 to 7 years of service, the modal rank for an individual returning from OIF.[3] Costs for E-5s

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2 We considered estimating these costs over a longer period, which is possible using this framework. However, we could not gain access to appropriate data that would enable us to reliably parameterize the model over a longer time for the military population.

3 Because we did not have access to data describing the joint distribution of age, rank, and years of service among returning veterans, we made the simplifying assumption that everyone in our synthetic cohort is a 25-year-

may differ from costs for other servicemembers because E-5s are relatively young and therefore have lower wages and a higher risk of suicide than other servicemembers. Average wages for E-5s are also lower than average wages for officers of comparable age. In general, it is not clear whether mental health–related costs for E-5s should be higher or lower than mental health–related costs for other servicemembers. To the extent that wages for E-5s are lower than wages for other personnel, the costs for E-5s will also be lower. However, to the extent that the risk of suicide for E-5s is relatively high, costs will be higher. In sensitivity tests, we considered alternative combinations of age, rank, and years of service. To develop total cost estimates, we then took a weighted average of costs for each rank considered (E-4, E-5, E-7, and O-2) to estimate an approximate average cost per returning servicemember.

Modeled individuals are randomly assigned a gender, race/ethnicity, education, military branch, rank, and age using distributions reported in published studies (*Medical Surveillance Monthly Report*, 2007; DoD Office of the Under Secretary of Defense for Personnel and Readiness [OUSDPR], 2005; Congressional Budget Office, 2004; Defense Manpower Data Center, 2000). While assigned demographic characteristics are specific to rank, we were unable to model the joint distribution of these variables because of lack of data. Each individual has a probability of experiencing major depression, PTSD, or co-morbid major depression and PTSD based on prevalence rates found in published literature specific to OEF/OIF veterans (Hoge et al., 2004; Grieger et al., 2006; Milliken, Auchterlonie, and Hoge, 2007); for PTSD, these probabilities can increase over time to reflect delayed or gradual onset (Wolfe et al., 1999). Specifically, 5 percent of modeled individuals have PTSD immediately after returning from deployment, increasing to 15 percent over two years. Half of all individuals with PTSD are assigned co-morbid major depression. Another 7.2 percent of individuals are assigned major depression alone.

Figure 6.1 illustrates the model dynamics, with arrows showing possible transitions across states. Each state is defined by an individual's mental health status, treatment status, and employment status. For ease of presentation, this figure focuses on a single mental health condition, but our model incorporates three possible mental health conditions (PTSD, major depression, and co-morbid PTSD and major depression). As a simplifying assumption, we constrain individuals from switching across conditions. This assumption implies that, while some individuals in our model have a single mental health condition and some have co-morbid mental health conditions, no one with a single condition will ever develop a co-morbid condition, and no one with co-morbid conditions will ever recover from one condition but not the other. Appendix 6.A provides a "model map" that walks through the model dynamics in more detail.

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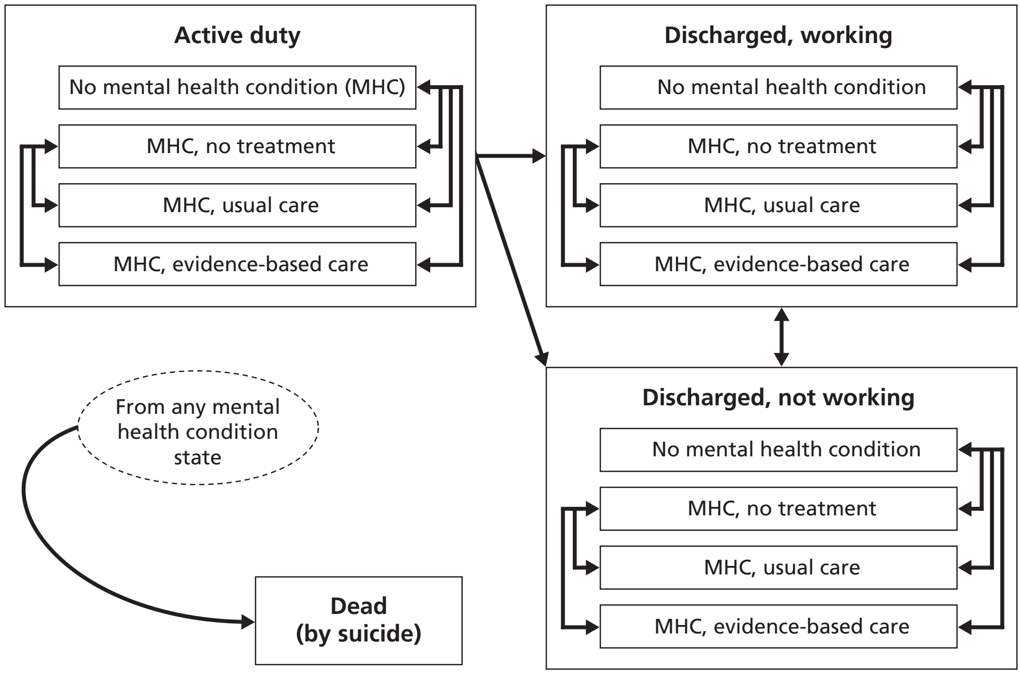
old E-5 returning to the states with 5 to 7 years of service. E-5 is approximately the modal rank of individuals returning from OIF, based on statistics reported in the *Medical Surveillance Monthly Report* (September–October 2007). Data reported by Hoge, Auchterlonie, and Milliken (2006) suggest that the median age of returning servicemembers who complete a post-deployment health assessment is approximately 25.

Figure 6.1
Model Dynamics



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Modeled individuals with a mental health condition have a probability of receiving evidence-based treatment or usual care, and these treatments influence the course of illness. Studies of the civilian population find that it is relatively common for individuals with a probable mental health condition to receive no treatment for these conditions. In a sample of adults with likely major depression or anxiety disorder interviewed in 1997 and 1998, 17 percent received no treatment at all during a one-year period (Young et al., 2001). A more recent study (Wang et al., 2005) found that about 43 percent of individuals with PTSD or major depression received no treatment during the past year. Among returning veterans, rates of care may be even lower. Hoge et al. (2004) found that only 23 to 40 percent of veterans returning from OEF and OIF who screened positive for a probable mental health condition, including major depression and post-traumatic stress disorder, sought care within three to four months of returning from deployment. Our survey (discussed in Chapter Four) found that approximately 50 percent of post-deployed servicemembers with mental health conditions received any treatment. Using figures reported in Hoge et al. (2004), Young et al. (2001), and Wang et al. (2005), we model a “status quo” scenario in which 30 percent of individuals in need get any care and 30 percent of the care that the individuals receive is evidence-based. We then consider alternative situations in which (1) 50 percent of individuals in need get treatment and 30 percent of treatment is evidence-based, (2) 50 percent of individuals in need get treatment and all treatment is evidence-based, and (3) 100 percent of individuals in need get evidence-based treatment.

Details on the dosages of medication, psychotherapy, and maintenance medication provided for evidence-based and usual care for each of the three conditions are discussed in Appendix 6.B (see Tables 6.B.1 and 6.B.2). We assigned treatment success probabilities based on remission rates reported in existing literature (Schnurr et al., 2007; Kessler et al., 1995; Keller et al., 2000; Dimidjian et al., 2006; Ludman et al., 2007; Wells et al., 1992; Kocsis et al., 1988). Table 6.2 shows the probability of remission after three months in each treatment assignment.

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. Once in remission, labor-market outcomes will, on average, improve. Individuals in remission have a probability of relapsing, based on figures reported in published studies (Perconte, Griger, and Bellucci, 1989; Melfi et al., 1998; Vittengl et al., 2007). The evidence on the probability of relapse conditional on successful treatment for PTSD is relatively thin, and estimates of the probability of relapse conditional on successful treatment for major depression have ranged considerably across studies (Vittengl et al., 2007). As a result, we explore alternative assumptions regarding relapse in our high- and low-cost scenarios.

Based on their mental health state and demographic characteristics, individuals are assigned labor-market outcomes and labor-market transitions for each quarterly period included in our model. For example, each person currently on active duty has a military wage (based on rank and years of service) and a quarterly probability of leaving military service based on rates reported in Hoge, Auchterlonie, and Milliken (2006), measured from the date of return from deployment. Military wages are calculated using pay tables reported by DoD,[4] and promotion probabilities are derived from the 2007 *Defense Manpower Requirements Report* (DoD OUSDPR, 2006). A mental health condition influences DoD career trajectories by increasing the probabil-

Table 6.2
Remission Probabilities Following Three Months of Illness

	Treatment Assignment			
Condition(s)	Evidence-Based Treatment	Usual Care	No Care	Sources
PTSD or co-morbid PTSD and major depression	39%	30%	~5%[a]	Schnurr et al. (2007) Kessler et al. (1995) Wolfe et al. (1999)
Major depression alone	48%	40%	12%	Keller et al. (2000) Dimidjian et al. (2006) Ludman et al. (2007) Wells et al. (1992) Kocsis et al. (1988)

[a] Remission rates are derived from Wolfe et al. (1999)

4 See DoD's "Military Pay and Benefits" Web page (2008b).

ity of leaving the military (Hoge, Auchterlonie, and Milliken, 2006). We do not allow mental health treatment to affect promotions within DoD because we do not have data on how this treatment would affect career outcomes, and—intuitively—we are not sure of the expected direction of this effect. To the extent that mental health treatment improves productivity, it might lead to quicker promotion. However, if mental health treatment can affect performance reviews, it could potentially have adverse consequences for career progression.

Individuals who have left active duty are assigned a probability of working in the civilian sector and a civilian wage—these outcomes are influenced by mental health status as well as other factors, such as age and sex. We calculated wages and employment probabilities using data on veterans in the March 2007 Current Population Survey (CPS). For those with a mental health condition, we reduced the probability of working and wages conditional on working based on a study of mental health condition and productivity in a group of Vietnam veterans (Savoca and Rosenheck, 2000); these estimates imply a 15.75-percent wage reduction for PTSD and a 45.23-percent wage reduction for major depression. Individuals with co-morbid PTSD and major depression were assigned the same wage reduction as individuals with major depression alone. Because the reduction in wages associated with major depression in this study is high relative to similar studies of the civilian population (Ettner, Frank, and Kessler, 1997), we used a more conservative figure in our low-cost scenario.

Few studies besides Savoca and Rosenheck (2000) have examined wage reductions associated with PTSD or co-morbid PTSD and major depression, so it is difficult to compare the assumptions used in our model with other literature. However, a recent report by CNA Corporation (Christensen et al., 2007) finds that—for recently discharged veterans in their twenties and thirties with Service-connected disabilities—the probability of working is 5 percent lower than the probability for comparable veterans with no disability, and wage rates are approximately 14 percent lower. Although these rates are slightly lower than the rates reported by Savoca and Rosenheck (2000), they combine physical and mental disabilities. Additional analyses in the CNA report confirm that wage differentials are higher for individuals with mental health conditions.[5]

Individuals who have left active duty also have a probability of joining the Reserves, but—in the absence of any data on how a mental health condition influences the chance of joining the Reserves—the probability of joining the Reserves does not vary with mental health status.

Military compensation policies imply that wages for active duty personnel are almost completely determined by rank and years of service. Kilburn, Louie, and Goldman (2001) analyzed this issue empirically. They found that there were statistically significant differences in total compensation, including benefits, across enlisted per-

5 For example, the annual earned-income loss for an individual with a 10-percent mental health disability rating is $7,676, compared with $2,543 for an individual with a 10-percent physical disability rating.

sonnel, but that these differences were small and driven by years of service and number of dependents.[6] As a result, a mental health condition will not influence DoD salaries through a direct reduction in wage. However, given the civilian literature summarized in Part III (see Chapter Five) finding an association between mental health conditions and reduced wages (Ettner, Frank, and Kessler, 1997; Savoca and Rosenheck, 2000), higher missed days at work (Druss, Rosenheck, and Sledge, 2000; Kessler, Borges, and Walters, 1999), and poorer work performance (Wang et al., 2004; LeBlanc et al., 2007), we think it is likely that a mental health condition would indirectly reduce DoD salaries through a decreased likelihood of promotion and through increased "presenteeism." Hosek and Mattock (2003) find evidence to substantiate the hypothesis that DoD personnel of lower "quality" (where quality is measured using educational attainment and Armed Forces Qualification Test scores) have a greater length of time until promotion. Stewart et al. (2003) find that depressed individuals lose approximately 4.6 hours per workweek because of "presenteeism," or reduced performance during work hours. For civilian workers, we anticipate that lower productivity (e.g., presenteesim) among individuals with mental disorders would be accounted for in wage differences; thus, the cost of reduced productivity is borne by the worker, who is paid less. However, since military wages cannot adjust as easily, the cost of presenteeism among active duty servicemembers may be disproportionately borne by DoD, which pays workers a fixed salary for lower-quality work. Because we have no data that would enable us to quantify the combined effect of reduced promotion probabilities and increased presenteeism for active duty servicemembers, our baseline scenario assumes that productivity within DoD is reduced by half of the civilian productivity-reduction factor found in Savoca and Rosenheck (2000). Thus, for a servicemember with PTSD, DoD wages are reduced by a factor of 7.88 percent; for a servicemember with major depression or co-morbid PTSD and major depression, DoD wages are reduced by a factor of 22.62 percent. In our low-cost scenario, we assumed that mental health conditions have no effect on wages within DoD; in our-high cost scenario, we assumed that mental health conditions have the same effect for active duty and non–active duty workers.

At each quarter, individuals with a mental health condition have a probability of death from suicide.[7] Because our model time frame is only two years and our population is relatively young, we did not allow for other causes of death. We assigned the probability of a suicide attempt using the age-specific probability of a suicide attempt prior to treatment for major depression in a population of veterans (Gibbons et al.,

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6 We accounted for dependents in our model by assuming that 50 percent of personnel are married.

7 It is the tradition in cost-of-illness studies, whether estimated for a year or over a period of time, to include the full lifetime loss associated with early death at the time the death occurs (Hodgson and Meiners, 1979; Hodgson and Meiners, 1982; Rice, Kelman, and Miller, 1991; Harwood, Fountain, and Fountain, 1998). Given that suicide is our only method for dying, this cost category is large relative to the other cost categories, because the present value of the individual's life is assigned fully to the period when the death occurs. Other cost categories consider only actual costs incurred during that period, consistent with the cost-of-illness approach.

2007). The probability of dying conditional on a suicide attempt is derived from the *2006 Army Suicide Event Report* (U.S. Army, 2007). Because both the rate of attempted suicide and the rate of suicide conditional on attempt used in our analysis are based on suicide attempts that led to contact with the health care system, these estimates likely understate the true costs of suicide. Specifically, we were unable to capture either "minor" suicide attempts that required no medical treatment or serious attempts and completions that might have been recorded as accidents (e.g., single-car crashes). To address this issue, we increased the probability of a suicide attempt by 25 percent in our high-cost model estimate. In our low-cost estimate, we decreased the probability of a suicide attempt for individuals with PTSD and co-morbid PTSD and depression, based on a recent study suggesting that depressed veterans have a higher rate of suicide attempt than veterans with co-morbid PTSD and depression (Zivin et al., 2007).

Consistent with research showing a high rate of attrition among active duty personnel hospitalized for mental disorders (Hoge et al., 2002) and conversations with servicemembers suggesting a limited tolerance within DoD for maintaining personnel who have had a suicide attempt, we assumed that 80 percent of individuals attempting suicide will leave DoD within three months. In all model scenarios, we assumed that individuals without mental health conditions and individuals in remission from mental health conditions have a zero probability of suicide.

Costs in our model came from treatment expenditures, lost productivity, and costs associated with suicide. Because the medical costs of evidence-based treatment (pharmaceutical costs and psychotherapy visits) are higher than the medical costs associated with usual care and no care, any cost savings associated with evidence-based care compared with usual care stem from secondary effects. Such savings include better productivity outcomes, lower risk of suicide, and fewer treatment episodes over the modeled time frame (because of both a higher probability of treatment success and, in the case of major depression, a lower probability of relapse). Table 6.3 describes the source of data for our cost estimates.

We assumed that all active duty personnel receive mental health treatment through the TRICARE system. In theory, individuals who have been discharged from DoD can get care either through the VA or through private health insurance offered by an employer, a spouse's employer, or an alternative source. Because pharmaceutical costs can vary substantially depending on whether care is provided through the VA or through alternative sources, we tested the sensitivity of our estimates to various assumptions about prescription drug costs for discharged personnel in our high- and low-cost scenarios. In our baseline scenario, we assumed that 35 percent of discharged veterans get prescription drugs through the VA, based on VA utilization among OEF/OIF veterans reported by the Veterans Health Administration Office of Public Health and Environmental Hazards (Veterans Health Administration, 2007).

We assumed that medical care costs related to suicide, which come from Corso et al. (2007), are equivalent for active duty and discharged personnel. The cost of lives lost

Table 6.3
Data Sources for Cost Information

Cost Component	Active Duty Personnel	Discharged Personnel and Reservists
Psychotherapy, primary, and specialty care costs	TRICARE Reimbursement Rates[a]	Medicare Reimbursement Rates[b]
Pharmaceutical costs	DoD Pharmacoeconomic Center (2004)	Fleming (2007b); Dobscha, Winterbottom, and Snodgrass, (2007)
Wage rates	Pay Tables, Office of the Secretary of Defense[c]	Calculated using veterans from the March 2007 Current Population Survey
Value of lives lost to suicide	Viscusi and Aldy (2003)	Viscusi and Aldy (2003)
Medical care costs associated with suicide	Corso et al. (2007)	Corso et al. (2007)

[a] TRICARE, "Allowable Charges," Web page, no date.

[b] Department of Health and Human Services, Centers for Medicare and Medicaid Services, "Physician Fee Schedule Search," Web page, no date.

[c] Department of Defense, "Pay and Allowances," Web page, no date-a.

to suicide comes from a review by Viscusi and Aldy (2003), who found that most studies of the value of a statistical life yield estimates in the range of $4 million to $9 million in 2000 dollars. Wallsten and Kosec (2005) used the midpoint of this range ($6.5 million) as their estimate of the value of a life in 2000 and inflated it for the year in which they were evaluating costs. We used the same approach and inflated the $6.5-million estimate to 2007 price levels, giving us a value of a statistical life of $7.5 million. The studies used to derive this estimate are based on wage-risk trade-offs, whereby researchers use differences across occupations in wage and risk of dying to estimate an approximate value of life for a statistical individual.[8] In theory, these estimates should capture all costs associated with death that would conceivably be valued by a worker, including lost quality of life, grief and loss to family members, and pain and suffering.

There is substantial uncertainty in our estimates owing to uncertain parameters, uncertainty about the prevalence of mental health conditions, uncertainty about which costs are causally attributable to PTSD and major depression, and other factors. We attempted to convey this uncertainty in our results in several ways. In our analysis of E-5s, we calculated high, low, and "baseline" cost estimates that allow key parameters to vary, using ranges of parameters found in the literature. Rather than allowing each model parameter to vary across the three scenarios, we only varied model parameters for which there was a great deal of uncertainty and that were likely to have a large

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[8] The literature draws a distinction between a statistical life and an identified life. A *statistical life* represents a hypothetical individual who might be saved by a particular intervention or policy change. An *identified life*, in contrast, is an actual person. The value of an identified life would far exceed the value of a statistical life and cannot be appropriately valued using economic techniques.

bearing on costs (e.g., parameters related to suicide and productivity). Table 6.4 shows the assumptions that varied across the three cost scenarios that we model. Because of the high degree of uncertainty regarding the number of completed suicides that might occur as a result of PTSD or major depression,[9] we consistently present results with and without costs associated with lives lost to suicide. Because prevalence rates for mental health conditions in this population are uncertain, and because there is uncertainty regarding how many people receive evidence-based care, usual care, and no care, we show costs per case for each possible treatment regimen. We also present costs for four alternative personnel types (E-4, E-5, E-7, and O-2) to demonstrate the potential difference in outcomes stemming from evaluating individuals with different

Table 6.4
Assumptions That Vary Across Model Scenarios

Assumption	Baseline	Low-Cost	High-Cost
DoD earnings for those on active duty	PTSD reduces wage by 7.88%, major depression or co-morbid PTSD and major depression reduce the wage by 22.6%	DoD wages are unrelated to a mental health condition	PTSD reduces wage by 15.75%, major depression or co-morbid PTSD and major depression reduce the wage by 45.23%
Medication costs for discharged personnel	35% of discharged personnel get prescriptions at the VA-negotiated price	All discharged personnel get prescriptions at the VA-negotiated price	All discharged personnel get prescriptions through private health insurance
Wage adjustment for discharged personnel with major depression, or co-morbid major depression and PTSD	45.23% lower than CPS estimate	15.75% lower than CPS estimate	45.23% lower than CPS estimate
Relapse rates for major depression	54% relapse over 2 years	26% of those with evidence-based treatment relapse over 2 years; 36% of those with usual care or no care relapse over 2 years	54% of those with evidence-based treatment relapse over 2 years; 75% of those with usual care or no care relapse over 2 years
Relapse rates for PTSD	55% relapse over 2 years	25% relapse over 2 years	55% relapse over 2 years
Rate of attempted suicide	Use age-specific rates reported in Gibbons et al. (2007)	Use age-specific rates reported in Gibbons et al. (2007), but reduce by 25% for individuals with PTSD or co-morbid PTSD and major depression	Use age-specific rates reported in Gibbons et al. (2007), but increase by 25% to account for attempts and completions that were missed or not recorded as suicide

[9] The *2006 Army Suicide Event Report* (U.S. Army, 2007) did not find a direct relationship between increased deployment and suicide, and it noted that most soldiers who completed suicide did not have a prior psychiatric condition. Further, suicide rates found in the ASER were lower than gender-matched suicide rates for the U.S. population.

wage profiles. In addition, we estimated total costs using several alternative assumptions about the fraction of servicemembers who receive any treatment and who receive evidence-based treatment.

Finally, an important advantage of the microsimulation framework is that it allows us to capture uncertainty that exists in event probabilities and outcomes, because individuals in our model experience events and outcomes with chance rather than with certainty. For example, a modeled individual with PTSD has a 39-percent chance of recovery following an episode of evidence-based treatment. But, in each model run, some individuals recover and some individuals remain sick. Because our model population is relatively large (a minimum of 20,000 observations in each run), the law of large numbers usually implies that separate model runs will produce similar results. But, for outcomes that are very rare or very uncertain, alternative model runs can produce markedly different outcomes. By being run several times and analyzing differences in outcomes across runs, our model can shed light on which cost components are relatively stable and which cost components can vary depending on the population, circumstances, and random chance. A more detailed discussion of the model parameters, assumptions, and architecture—including a comparison of several alternative model runs—can be found in the technical appendixes to this chapter (Appendixes 6.A and 6.B).

Model Limitations

All models, including both microsimulation and standard accounting models, are abstractions from reality and rely on simplifications and assumptions in order to be tractable and computationally feasible. A disadvantage of microsimulation models is that, because the methodology is complex, it can be difficult to effectively convey these omitted details and the underlying assumptions. Another challenge that is particularly relevant to microsimulation models is that model results can be highly dependent on the parameters used to assign event probabilities—such as the probability of developing a mental health condition, the probability of working conditional on having a mental health condition, and expected salary conditional on working. If these parameters are incorrect, model results will be misleading.

The challenge of assigning appropriate model parameters is nontrivial in the case of mental health conditions stemming from the conflicts in Afghanistan and Iraq. The population that we are trying to model—previously deployed veterans—is very unique, and relatively few studies focus specifically on these individuals. While data on prevalence of illness, attrition conditional on mental health conditions, and the probability of receiving treatment come from studies of servicemembers returning from OEF and OIF, most other parameters are drawn from data on veterans of prior conflicts (e.g., the Gulf War and the Vietnam War) or from the civilian population. Parameters related to DoD career transitions were particularly difficult to estimate with available data. In particular, we had no information on how a mental health condition affects DoD promotion probabilities among those who continue to serve—a particularly important parameter, given that DoD wages are determined almost entirely by promotion. Further, with the exception of a recent CNA report (Christensen et al., 2007), there is limited information on discharged personnel's labor-market experiences immediately following separation from DoD or on how a mental health condition affects the probability of joining the Reserves. There is also limited literature on the relationship between PTSD and productivity.

Model limitations that we view as particularly important are listed below. In general, these limitations are due either to data constraints or to simplifications that we made in order to develop this model within a limited time horizon. Many of these limitations could be at least partially addressed with additional time, data, and resources:

- There was a lack of data on how mental health conditions affect DoD wages and career outcomes.
- Employment status was assumed to have no effect on mental health.
- We did not allow mental health treatment to directly influence DoD career outcomes (although treatment can indirectly influence career outcomes if it causes mental health status to improve).
- Model time horizon was limited to two years.
- Characteristics assigned to individuals (e.g., age, race, sex, education) were generally based on univariate rather than joint distributions of these characteristics.
- Mental health prevalence used in the model was based on population averages and was not specific to age, rank, gender, race, or other characteristics.
- We made simplifying assumptions about career transitions within the Reserves (apart from those attempting suicide, mental health has no influence on the probability of joining the Reserves; we did not model promotion among reservists).
- The probability of mental health treatment success was independent of previous treatment outcomes.
- Modeled suicides and suicide attempts captured only suicides that would have led to contact with the health care system.
- Data on remission from PTSD following evidence-based treatment were limited, and estimates used in the model came from a sample of female veterans.
- We assumed that no servicemembers redeploy within the model time horizon.

Qualitatively, we think the most important limitations stem from (1) the fact that we are not certain of the full number of suicides and suicide attempts that may be causally related to PTSD and depression and (2) the fact that wage reductions for active duty servicemembers with mental health conditions are unclear. Because we were missing suicide attempts and completions that do not lead to contact with the health care system (or lead to contact with the system but are recorded as accidents), we think that we were likely underestimating the costs resulting from suicide. However, we were less certain of the direction of bias inherent in our assumptions about productivity. As a result, our low-cost, "baseline," and high-cost estimates allow for substantial difference in the wage reductions associated with mental disorders, particularly for active duty personnel.

In addition to these limitations, at least two additional costs are associated with evidence-based treatment that were not considered in our model. First, there could be costs associated with implementing programs that exceed the costs captured in our model. Such costs would include training providers in evidence-based practices and providing outreach to servicemembers to encourage them to seek care. Yet, while we did not address these costs in our model, prior studies have found that vigorous outreach aimed at moving depressed workers into evidence-based care leads to cost savings from the employer's perspective (Wang et al., 2007). Second, there could be spillover costs associated with bringing veterans into the health care system—for example, individuals who seek treatment at the VA for PTSD might be prompted to seek care for unrelated health concerns. These spillover costs are particularly difficult to evaluate, both because it is hard to know whether the additional utilization would have occurred without the mental health visit and because the additional utilization could either create new costs (e.g., costs for unnecessary care) or save costs downstream (e.g., early detection of illness). More generally, the model is only able to consider anticipated costs—in some cases, there may be additional costs that are completely unanticipated.

Finally, our model was designed to analyze the effects of guideline-concordant treatment. There are two reasons that treatment as practiced might differ from suggested guidelines. First, patients may not adhere to treatments with perfect fidelity. Because figures from the randomized control studies used to parameterize the model (Schnurr et al., 2007; Ludman et al., 2007; Keller et al., 2000; Casacalenda, Perry, and Looper, 2002) were based on the intent-to-treat methodology, our estimates incorporate lack of patient fidelity. Second, provider fidelity may be imperfect, leading care as implemented to be less successful than care provided in a controlled setting. Our analysis assumed that care is implemented as intended, in part because our intent was to analyze the potential costs and benefits associated with appropriately implemented care. Our cost estimates for usual care can be viewed as a lower bound of the potential effect of poorly implemented evidence-based care. However, we did not attempt to model evidence-based care *as-implemented* separately from evidence-based care *as-intended*.[10]

Despite these limitations, we have done our best to produce what we believe will be a conservative estimate of the total cost. When uncertain about the actual cost of particular services or outcomes, we used low estimates of these costs. In addition, we excluded a range of additional outcomes that are believed to be associated with each of

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[10] Previous literature has found that quality-of-care improvements for depression implemented in local, "naturalistic" care settings have produced cost savings (Schoenbaum et al., 2001).

these conditions and focused instead on outcomes for which we have reasonably good data: treatment, productivity, and suicide.

Model Results

Table 6.5 shows the predicted costs over two years associated with PTSD and major depression for a cohort of 50,000 E-5s (this is approximately the number of E-5s that returned from OIF in 2005, based on data reported in the *Medical Surveillance Monthly Report*, September–October 2007). The baseline, low-, and high-cost scenarios incorporate different assumptions about wage reductions for individuals with mental health conditions, relapse probabilities, and rates of suicide attempt. A full description of the differences across scenarios is provided in Table 6.4. We assumed that 30 percent of individuals with mental health conditions get treatment and that—of this 30 percent—30 percent get evidence-based treatment. Throughout this monograph, we refer to these rates of treatment receipt (30 percent in need get treatment and 30 percent of treatment is evidence-based) as the "status quo." We think that these proportions approximate the likelihood of receiving any care and evidence-based care, given figures reported in prior studies (Hoge, 2004; Wang et al., 2005; Young et al., 2001).

Our baseline results indicate that, for 50,000 E-5s returning from OEF and OIF, two-year costs associated with PTSD and major depression range from $119.8 million to $204.7 million (at 2007 price levels), depending on whether or not we included the value of lives lost to suicide in our estimates. We present results with and without costs stemming from suicide deaths because the cost of a completed suicide is extremely high and—even among those with a mental disorder—the probability of committing suicide is very low. As a result, model estimates can vary widely depending on the number of suicides occurring in a particular model run. In a series of ten alternative model runs (shown in Appendix Table 6.B.5), the number of suicides ranged from 4 to 11, and, as a consequence, total cost figures ranged from $147.3 million to $204.7 million when we included the value of lives lost to suicide in our estimates. Because of uncertainty regarding the suicide rate and potential volatility in cost estimates that include the

Table 6.5
Status Quo Cost Projections for 50,000 E-5s

	Baseline	Low-Cost	High-Cost
Total cost, including lives lost to suicide	$204,691,652	$120,736,359	$231,455,009
Total cost, excluding lives lost to suicide	$119,829,381	$51,184,350	$149,009,345
Total number of suicides	11	9	11

NOTE: Status quo assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care.

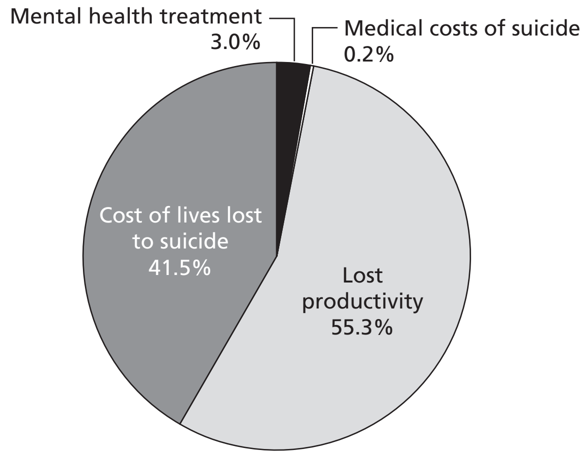
value of lives lost to suicide, we present results with and without suicide mortality costs in all subsequent tables.

Table 6.5 also shows that there is a wide range between our low- and high-cost estimates. This range primarily reflects our uncertainty about how much a mental health condition affects the productivity of DoD personnel. In the low-cost scenario, we assumed that a mental health condition has no effect on productivity for active duty personnel, and—when we separate productivity costs out of the figures reported in Table 6.5 (not shown)—estimated productivity losses account for $46.5 million. In our high-cost scenario, in which we assumed that a mental health condition has the same effect on productivity for active duty personnel as it does for civilian veterans, productivity losses (not shown in Table 6.5) account for $141.6 million. Figures 6.2 and 6.3 show the distribution of costs for our baseline model, with and without the cost of lives lost to suicide, under our status quo treatment assumptions. In both cases, lost productivity accounts for the majority of costs—making up 55.3 percent of total costs when we include suicide mortality and 94.5 percent of total costs when we exclude suicide mortality.

One of our primary questions is: How much money could be saved by investing in evidence-based treatment? Tables 6.6a and 6.6b show the expected costs, and total savings, associated with increasing the share of E-5s with PTSD or major depression that get mental health treatment. Relative to the status quo, in which 30 percent get treatment and 30 percent of treatment is evidence-based, we considered scenarios in which 50 percent of those in need get treatment and 30 percent of treatment is evidence-based; in which 50 percent of those in need get treatment and all treatment is evidence-based; and in which 100 percent of those in need get evidence-based treatment.

Using our baseline model and including the costs of lives lost to suicide (Table 6.6b, Panel A), we predicted that society could save money by increasing the share of individuals who received any treatment from 30 to 50 percent and that even more could be saved if all treatment were evidence-based. We predicted that society could save approximately $86.2 million over two years if all of the 50,000 E-5s in our model with PTSD or major depression received evidence-based treatment. If we exclude the value of lives lost to suicide, the results are not as straightforward (Table 6.6b, Panel B). Although we predicted that society could save money by increasing the share of individuals who receive treatment from 30 to 50 percent, there is a net loss associated with ensuring that 50 percent of individuals in need receive evidence-based treatment. This result stems from the fact that evidence-based treatment is expensive and that the marginal benefit of evidence-based treatment over usual care is small when we do not account for lives lost to suicide. Put differently, if we exclude the cost of lives lost to suicide, our model predicts that cost savings come primarily from providing treatment to individuals who are currently untreated, rather than from moving those in usual care to evidence-based care.

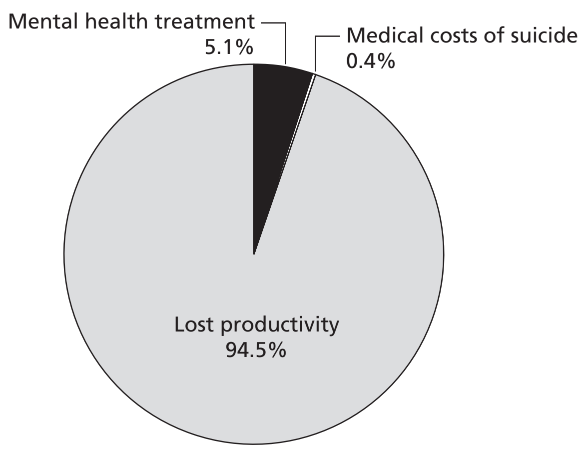
Figure 6.2
Status Quo Distribution of Costs, Including Suicide Mortality



NOTE: *Status quo* assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care.

RAND *MG720-6.2*

Figure 6.3
Status Quo Distribution of Costs, Excluding Suicide Mortality



NOTE: *Status quo* assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care.

RAND *MG720-6.3*

Table 6.6a
Cost Projections with Alternative Treatment Assumptions, Cohort of 50,000 E-5s

Treatment Scenario	Baseline	Low-Cost	High-Cost
A. Cost for 50,000 E-5s, including lives lost to suicide			
50% receive treatment; 30% of treatment is evidence-based	$190,754,753	$107,221,965	$212,216,948
50% receive treatment; all treatment is evidence-based	$172,023,750	$110,606,850	$210,119,625
100% receive evidence-based treatment	$118,450,500[a]	$80,205,750	$159,927,150
B. Cost for 50,000 E-5s, excluding lives lost to suicide			
50% receive treatment; 30% of treatment is evidence-based	$115,582,035	$51,063,450	$143,660,408
50% receive treatment; all treatment is evidence-based	$122,325,450	$57,978,225	$150,906,825
100% receive evidence-based treatment	$118,450,500[a]	$64,590,750	$144,780,900

[a] Costs associated with evidence-based treatment are the same with and without the value of lives lost to suicide because there were no suicides in our evidence-based care group. Although the model allows for suicides among those with evidence-based care, suicides rarely occur in this group because the probability of suicide is low and individuals with evidence-based care are, on average, affected by the condition for a shorter period of time than individuals with usual care or no care.

Table 6.6b
Projected Savings Relative to Status Quo with Increased Treatment, Cohort of 50,000 E-5s

Treatment Scenario	Baseline	Low-Cost	High-Cost
A. Savings relative to status quo, including cost of lives lost to suicide			
50% receive treatment; 30% of treatment is evidence-based	$13,936,899	$13,514,394	$19,238,061
50% receive treatment; all treatment is evidence-based	$32,667,902	$10,129,509	$21,335,384
100% receive evidence-based treatment	$86,241,152	$40,530,609	$71,527,859
B. Savings relative to status quo, excluding cost of lives lost to suicide			
50% receive treatment; 30% of treatment is evidence-based	$4,247,346	$120,900	$5,348,937
50% receive treatment; all treatment is evidence-based	–$2,496,069	–$6,793,875	–$1,897,481
100% receive evidence-based treatment	$1,378,881	–$13,406,400	$4,228,445

NOTES: *Status quo* assumes that 30 percent of those in need get treatment and that 30 percent of treatment is evidence-based. Positive entries in the table indicate cost savings, whereas negative entries represent cost increases.

Because there is uncertainty regarding the total number of cases of PTSD and major depression, and because our cohort of 50,000 E-5s does not encompass the total spectrum of returning veterans, it is informative to consider costs per case in addition to total costs. Table 6.7 shows the predicted two-year costs per case for each modeled condition and type of treatment.

For E-5s, evidence-based treatment for major depression saves money relative to no care and—in most cases—relative to usual care (an exception is that evidence-based care is slightly more expensive than usual care in the low-cost scenario when we exclude the cost of suicide mortality). However, results are not as clear when we consider PTSD and co-morbid PTSD and major depression. In our baseline scenario, when we included the cost of suicide mortality, evidence-based care for PTSD or co-morbid PTSD and depression saves money relative to no care, but not relative to usual

Table 6.7
Predicted Two-Year Costs per Case, E-5

Condition, Type of Treatment	Baseline	Low-Cost	High-Cost
A. Cost per case, including suicide mortality			
PTSD, no care	$11,986	$7,671	$13,007
PTSD, usual care	$13,935	$4,246	$10,661
PTSD, evidence-based care	$7,933	$10,264	$12,914
Co-morbid PTSD/major depression, no care	$17,746	$6,846	$14,759
Co-morbid PTSD/major depression, usual care	$14,356	$3,529	$12,469
Co-morbid PTSD/major depression, evidence-based care	$13,641	$6,761	$16,923
Major depression, no care	$31,695	$24,047	$43,386
Major depression, usual care	$18,299	$11,494	$21,995
Major depression, evidence-based care	$10,430	$4,545	$13,344
B. Cost per case, excluding suicide mortality			
PTSD, no care	$5,635	$4,495	$6,750
PTSD, usual care	$5,664	$4,246	$6,462
PTSD, evidence-based care	$7,933	$6,100	$8,875
Co-morbid PTSD/major depression, no care	$11,781	$3,863	$14,759
Co-morbid PTSD/major depression, usual care	$10,176	$3,529	$12,469
Co-morbid PTSD/major depression, evidence-based care	$13,641	$6,761	$16,923
Major depression, no care	$16,914	$5,562	$21,215
Major depression, usual care	$11,051	$4,355	$14,746
Major depression, evidence-based care	$10,430	$4,545	$13,344

care. Without accounting for the costs associated with lives lost to suicide, evidence-based care for PTSD or co-morbid PTSD and depression is more costly even than no treatment. The less robust results for PTSD reflect the relatively high cost of treatment for this disorder, the limited evidence on the benefits of treatment for PTSD (Institute of Medicine, 2007), and a relatively small wage reduction associated with PTSD (Savoca and Rosenheck, 2000).

Table 6.7 shows that, occasionally, per-case costs estimated in the high-cost scenario are *lower* than per-case costs found in the baseline scenario (e.g., for PTSD with usual care). This finding stems from the fact that there is volatility in suicide outcomes, and an additional suicide in the baseline group can increase costs substantially.[11] Figures 6.4 and 6.5 show the predicted cost per case associated with treatment for PTSD alone, PTSD and co-morbid major depression, and major depression averaged over ten model runs. By averaging across several runs, we reduced the volatility in suicide outcomes and increased the probability that the high-cost, baseline, and low-cost estimates will align in the expected order. These figures report the expected per-case costs for each mental health condition under the "status quo," in which 30 percent of individuals receive treatment and 30 percent of treatment is evidence-based.

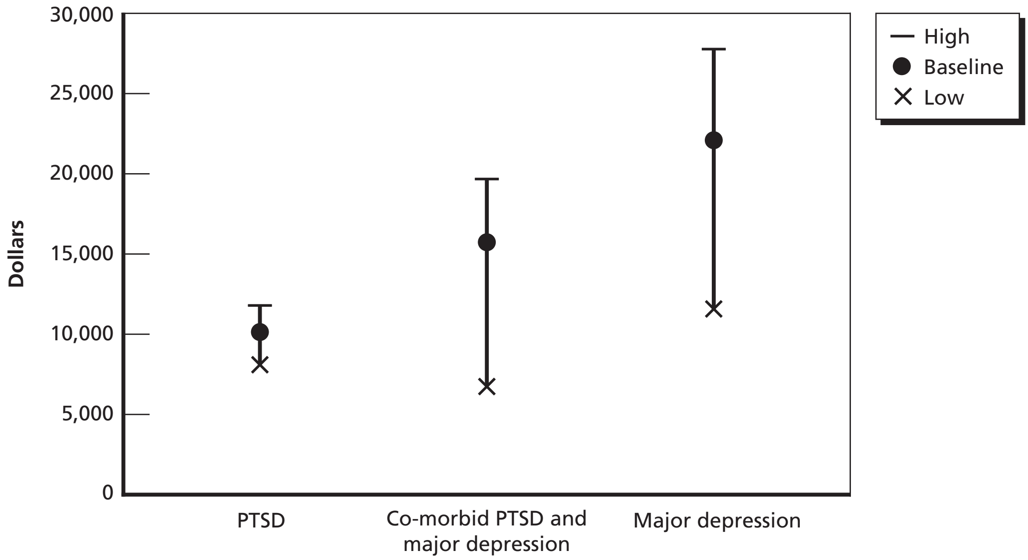
Figures 6.4 and 6.5 show that depression is the most costly outcome within two years post-deployment, followed by co-morbid depression and PTSD, and PTSD alone. Two-year costs are lower for co-morbid PTSD and major depression than they are for major depression alone because individuals in our model can develop late-onset PTSD with co-morbid major depression. As a result, individuals with co-morbid PTSD and major depression tend to be sick for a shorter period of time over two years, since some of these individuals develop illness near the end of the model time frame. A larger discussion of the model runs used to derive Figures 6.4 and 6.5 can be found in Appendix 6.B.

A drawback of our model is that it is specific to 25-year-old E-5s returning from deployment with 5 to 7 years of service. We restricted our cohort to this group because, when developing the model, we did not have access to data on the joint distribution of age, rank, and years of service among all returning veterans. Because rank and years of service jointly determine DoD salaries, and because productivity is the largest driver of costs, incorrect assumptions about the distribution of these variables could lead to erroneous cost projections. To get a sense of how cost projections might vary for alternative personnel types, we show in Table 6.8 results from the baseline cost scenario for three different combinations of rank, years of service (YOS), and age.

Cost estimates are different across personnel types because of age-specific differences in the probability of suicide and wide differences in salary, and because the model has a two-year duration. We estimated that annual earnings for a healthy service-

[11] Recall that suicides occur with an expected probability based on published studies, but the realized number of suicides in each model run varies.

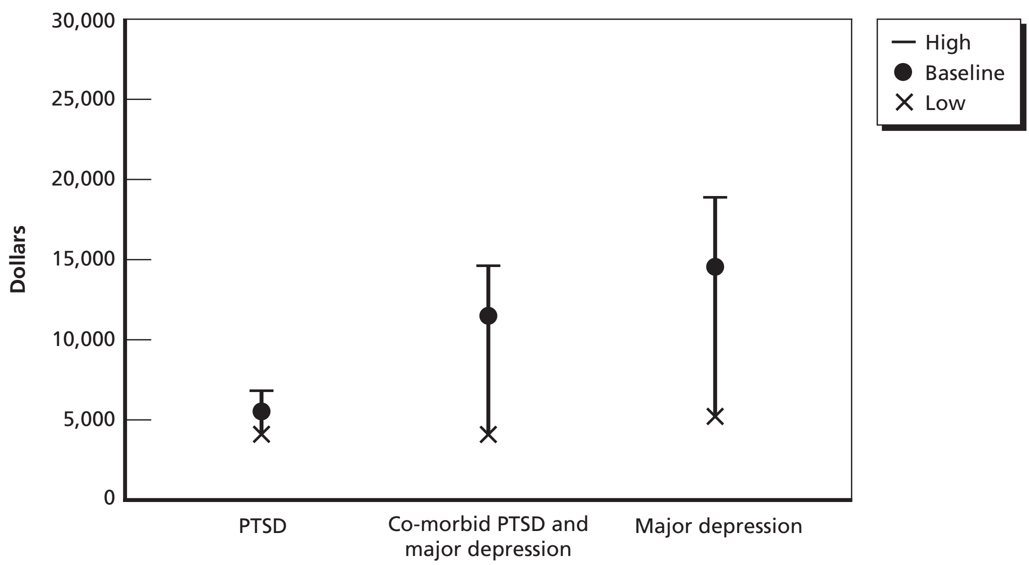
Figure 6.4
Average Two-Year Cost per Case for the Status Quo, Including Value of Lives Lost to Suicide



NOTE: *Status quo* assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care.

RAND *MG720-6.4*

Figure 6.5
Average Two-Year Cost per Case for the Status Quo, Excluding Value of Lives Lost to Suicide



NOTE: *Status quo* assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care.

RAND *MG720-6.5*

Table 6.8
Predicted Two-Year Cost per Case, Alternative Personnel Types

Condition, Type of Treatment	E-4, 20 Years Old, 2 YOS	E-7, 31 Years Old, 13 YOS	O-2, 24 Years Old, 1 YOS
A. Cost per case, including suicide mortality			
PTSD, no care	$8,205	$11,986	$14,768
PTSD, usual care	$4,717	$13,935	$12,431
PTSD, evidence-based care	$7,718	$7,933	$9,594
Co-morbid PTSD/major depression, no care	$17,645	$17,746	$25,591
Co-morbid PTSD/major depression, usual care	$8,606	$14,356	$15,887
Co-morbid PTSD/major depression, evidence-based care	$12,499	$13,641	$17,967
Major depression, no care	$28,674	$31,695	$34,005
Major depression, usual care	$13,033	$18,299	$17,495
Major depression, evidence-based care	$22,166	$10,430	$15,745
B. Cost per case, excluding suicide mortality			
PTSD, no care	$5,098	$5,635	$8,536
PTSD, usual care	$4,717	$5,664	$8,433
PTSD, evidence-based care	$7,718	$7,933	$9,594
Co-morbid PTSD/major depression, no care	$11,293	$11,781	$19,282
Co-morbid PTSD/major depression, usual care	$8,606	$10,176	$15,887
Co-morbid PTSD/major depression, evidence-based care	$12,499	$13,641	$17,967
Major depression, no care	$14,008	$16,914	$26,596
Major depression, usual care	$9,373	$11,051	$17,495
Major depression, evidence-based care	$10,429	$10,430	$15,745

NOTE: YOS = years of service.

member returning from Iraq or Afghanistan as an O-2 with one year of service would be $58,090, compared with $50,741 for an E-7 with 13 years of service, $40,119 for an E-5 with 5 to 7 years of service, and $34,174 for an E-4 with 2 years of service. As a result of these productivity differentials, costs are generally higher for O-2s and E-7s, particularly when we exclude costs from suicide mortality (E-7s have a lower suicide-attempt rate because they are older). However, despite the differences in magnitudes, the same patterns hold in terms of the benefits of evidence-based treatment. Specifically, evidence-based treatment clearly saves money relative to no care for major depression, but the evidence is less robust for PTSD.

Although we lacked detailed information on the joint distribution of age, rank, and years of service, the *Medical Surveillance Monthly Report* (September–October 2007) reports that 42 percent of servicemembers returning from Iraq in 2005 were between the ranks of E-1 and E-4, 36 percent were ranks E-5 or E-6, 8.9 percent were between ranks E-7 and E-9, and 13.1 percent were officers. If we use our baseline cohort and the alternative personnel types shown in Table 6.8 to proxy for the four grades reported in the *Medical Surveillance Monthly Report*, we can get an approximate cost per case for an "average" returning veteran. Table 6.9 shows average costs, assuming our status quo, in which 30 percent of all veterans with a mental health condition get treatment and 30 percent of treated individuals receive evidence-based care.

Depending on whether or not we include suicide-related mortality, approximate average costs per case over two years for *all returning servicemembers* range from $5,904 to $10,298 for PTSD, $12,427 to $16,884 for co-morbid PTSD and major depression, and $15,461 to $25,757 for major depression alone. Using the same approach, we could determine the DoD-wide cost savings that would accrue over two years if we increased the share of individuals receiving treatment or the share of individuals receiving evidence-based care (Table 6.10).

As with the earlier results, when we include the cost of lives lost to suicide, increasing the share of individuals receiving any treatment saves money. For co-morbid PTSD and major depression, and for major depression alone, the cost savings associated with increasing the share of people who receive any care exceed the cost savings associated with ensuring that all individuals receive evidence-based treatment. For example, for major depression, the cost savings relative to the status quo associated with moving

Table 6.9
Status Quo Cost per Case

Condition	E-4	E-5	E-7	O-2	Approximate DoD Average
A. Including cost of lives lost to suicide					
PTSD	$7,429	$12,031	$11,661	$13,812	$10,298
Co-morbid PTSD and major depression	$15,284	$16,665	$16,512	$22,867	$16,884
Major depression	$24,804	$26,968	$20,740	$28,895	$25,757
B. Excluding cost of lives lost to suicide					
PTSD	$5,254	$5,848	$5,214	$8,610	$5,904
Co-morbid PTSD and major depression	$10,837	$11,611	$14,366	$18,451	$12,427
Major depression	$12,713	$15,099	$17,758	$23,708	$15,461
Approximate share	0.42	0.36	0.089	0.131	

NOTE: *Status quo* assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care.

Table 6.10
Potential per-Case Cost Savings Relative to the Status Quo Associated with Increasing Treatment

Condition(s)	50% Get Treatment, 30% of Treatment Is Evidence-Based	50% Get Treatment, All Treatment Is Evidence-Based	100% Get Evidence-Based Treatment
A. Including cost of lives lost to suicide			
PTSD	$445	$819	$2,306
Co-morbid PTSD and major depression	$1,264	$551	$2,997
Major depression	$5,327	$2,483	$9,240
B. Excluding cost of lives lost to suicide			
PTSD	–$110	–$961	–$2,088
Co-morbid PTSD and major depression	$291	–$948	–$1,459
Major depression	$1,189	$1,214	$4,212

NOTES: *Status quo* assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care. Positive entries in the table indicate cost savings, whereas negative entries represent cost increases.

50 percent of people into treatment are $5,327 per case, compared with a cost savings of $2,483 per case associated with ensuring that 50 percent of those in need get evidence-based care. As a result, it looks as though the main margin on which society saves money is by moving individuals from no care to any care, as opposed to moving them from usual care to evidence-based care. However, we do not intend to suggest that usual care is preferable to evidence-based care, for two reasons. First, usual care is less effective than evidence-based care, so people with usual care are more likely to remain sick. Had we been able to account for all costs associated with PTSD and major depression, including lost quality of life, relationship strain, substance abuse, and violence, evidence-based care may well have saved money relative to usual care. Second, we model usual care as an average of different types of suboptimal care. In reality, some individuals who receive usual care might get treatments that are very similar to evidence-based care, while others get treatments that are very different. Without a more thorough model of the many different types of usual care, we cannot conclude that all usual care would produce cost savings.

When we exclude the cost of lives lost to suicide, expanding access to evidence-based care only saves money for major depression. For PTSD or co-morbid PTSD and depression, cost savings are small or negative when we increase the share of individuals who receive any treatment, and increased utilization of evidence-based treatment appears to increase costs. This finding reflects the relatively high cost of treatment for PTSD and the limited evidence on the benefits of treatment for PTSD.

Discussion

For a typical service person returning from Iraq or Afghanistan (an E-5 with 5 to 7 years of service), our baseline scenario predicts that two-year post-deployment costs range from $5,635 to $13,935 for PTSD, $10,176 to $17,746 for co-morbid PTSD and major depression, and $10,430 to $31,695 for major depression alone. Costs vary depending on the type of treatment received and on whether or not we include the value of lives lost to suicide in our estimates. Based on the *Medical Surveillance Monthly Report* (September–October 2007), approximately 50,000 E-5s returned from OIF in 2005, suggesting a total cost for E-5s of approximately $119.8 million over two years if we exclude suicide mortality, or $204.7 million if we include the value of lives lost to suicide. Our results also suggest that productivity is the largest driver of costs, accounting for between 55.3 and 94.5 percent of all costs attributable to PTSD and major depression.

Because productivity is specific to rank, age, and years of service, it is not clear that these cost figures can be generalized to the entire post-deployed population. In our sensitivity analyses (Table 6.8), we showed that the cost per case varied substantially depending on the years of service and rank of the individual considered. Nevertheless, we can develop an approximate average cost for all returning personnel if we take a weighted average of the four combinations of rank and years of service evaluated in our model. In Table 6.11, we apply the approximate cost per case to a population of 1.6 million—the approximate total number of servicemembers who have been deployed since 2001.

Using prevalence rates discussed earlier in this chapter, we can calculate approximate total two-year PTSD and major depression costs for all servicemembers who ever deployed. There are several caveats associated with this approach. First, these estimates represent costs incurred within the first two years after returning home from deployment, so they accrue at different times for different personnel. For servicemembers who returned more than two years ago and have not redeployed, these costs have already been incurred. However, this calculation omits costs for servicemembers who may deploy in the future, and it does not include costs associated with chronic or recurring cases that linger beyond two years. Costs presented in Table 6.11 are shown at 2007 price levels. Second, our cost figures assume that individuals who develop PTSD or major depression will never redeploy—an assumption that is almost surely violated in reality. Third, we are assuming that the total number of individuals who have ever deployed is a good estimate of the total number of individuals who return to the States. As of December 2007, there had been 3,439 hostile deaths in OEF and OIF,[12] a relatively small fraction of the total number of servicemembers deployed since 2001. Finally, we do not know how long the current conflicts will continue, and we cannot predict the total number of people who will deploy to Iraq or Afghanistan in the future.

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[12] See Department of Defense, "Military Casualty Information," Web page, 2008b.

With these caveats in mind, results in Table 6.11 suggest that total PTSD and major depression–related costs incurred for 1.6 million troops within the first two years after returning home could range from $4.0 billion to $6.2 billion, depending on whether we include the value of lives lost to suicide mortality in our figures (Panel A). These estimates are unavoidably imprecise because of uncertainty in estimates of prevalence rates, individuals' willingness to seek care, treatment efficacy, the effect of mental health conditions on productivity, and other estimates used to parameterize our model. Nevertheless, all of the parameters used in our model are grounded on prior literature, and we have done our best to be conservative in generating the cost predictions. Although our exact estimates may be imprecise, we think it is clear from this analysis that the costs are extremely high and that the majority of costs stem from lost productivity. By ensuring

Table 6.11
Approximate Societal Costs for All Servicemembers Returning in 2005

		Including Suicide Mortality		Excluding Suicide Mortality	
Condition(s)	**Prevalence[a]**	**Cost per Case**	**Total Cost**	**Cost per Case**	**Total Cost**
A. Costs for 1.6 million returning servicemembers, status quo (30% of those with need receive treatment, 30% of treatment is evidence-based)					
PTSD alone	120,000	$10,298	$1,235,779,451	$5,904	$708,454,129
Co-morbid PTSD and major depression	120,000	$16,884	$2,026,022,762	$12,427	$1,491,283,466
Major depression alone	115,200	$25,757	$2,967,212,796	$15,461	$1,781,137,099
Total cost			$6,229,015,009		$3,980,874,695
Condition(s)	**Prevalence[a]**	**Savings per Case**	**Total Savings**	**Savings per Case**	**Total Savings**
B. Savings for 1.6 million returning servicemembers, assuming that all individuals with need receive evidence-based treatment[b]					
PTSD alone	120,000	$2,306	$276,768,131	–$2,088	–$250,557,191
Co-morbid PTSD and major depression	120,000	$2,997	$359,655,122	–$1,459	–$175,084,174
Major depression alone	115,200	$9,240	$1,064,471,676	$4,212	$485,219,121
Total savings			$1,700,894,929		$59,577,757
% savings			27.3%		1.5%

[a] Prevalence estimates are derived by assuming that 15 percent of individuals got PTSD within two years and that half of these cases were co-morbid with major depression; 7.2 percent of individuals had major depression alone.

[b] Positive entries indicate cost savings, whereas negative entries represent cost increases.

that all individuals in need receive evidence-based treatment (Panel B), we could reduce two-year post-deployment costs from 1.5 to 27.3 percent.

Our model suggests that, within two years, evidence-based treatment would more than pay for itself *from a societal perspective*, largely through increased productivity. However, the benefits of evidence-based treatment are more pronounced for major depression than they are for PTSD and co-morbid PTSD and major depression. These results reflect uncertainty regarding appropriate treatment for individuals with PTSD, as well as a lower reduction in productivity associated with PTSD (which may—in part—stem from the limited literature on PTSD and productivity). These results should be interpreted carefully because of the dimensions of costs that we were unable to capture in our model. On the one hand, because we do not consider costs related to homelessness, domestic violence, family strain, and several other consequences of mental health conditions, the true benefit of providing evidence-based treatment may be even larger than predicted.

However, it is also likely that there are additional costs of evidence-based treatment that we have ignored in this model. One potential cost is that associated with implementation, such as training staff and expanding capacity to accommodate increased utilization. Costs associated with implementation could include one-time start-up costs, as well as ongoing costs associated with ensuring program performance. A second cost could include the cost of increased service utilization among veterans who access the health care system for mental health–related conditions (e.g., if visiting a provider to receive mental health care prompts an individual to seek care for unrelated problems). A broader issue is that—as with all models—we are only capturing costs that can be anticipated ahead of time. In reality, outcomes may be more complex than anticipated, which would lead to differential results. Despite these caveats, we think there is strong reason to believe that increased provision of evidence-based treatment could be a cost-saving strategy, particularly if DoD is able to provide evidence-based treatment to individuals who previously received no care.

The Cost of Deployment-Related Traumatic Brain Injury in 2005

TBI is an injury to the brain that may range in severity from relatively mild (e.g., concussion from exposure to a blast) to severe (e.g., penetrating head wound). We use a standard cost-of-illness approach to assess the costs associated with deployment-related TBI for the single year of 2005 because data are insufficient to build a microsimulation model. The costs examined include treatment and rehabilitation, TBI-caused death, suicide (both attempts and completions), and productivity losses.

Although the cost-of-illness approach requires fewer data to implement than the microsimulation approach, it is still data-intensive. Generating the cost of deployment-related TBI in 2005 requires estimates of the number of TBI cases, the utilization of treatment, the prevalence of the related outcomes (e.g., suicide, unemployment), and the associated costs. Because there are substantial differences in the outcomes and associated costs between mild and more severe cases of TBI, throughout this section we provide separate prevalence and cost estimates by severity (i.e., for mild and moderate/severe). In addition, because there is a high level of uncertainty around many of the needed estimates, we develop different assumptions and generate estimates for both a high- and a low-cost scenario. In the following sections we (1) discuss the previous literature estimating the cost of TBI, (2) outline the data used and the assumptions made to generate the cost estimate, (3) present our findings, and (4) discuss the policy implications.

Previous Estimates of the Cost of TBI

Because we are adopting a similar methodology to that which has been applied in the past, it is important to provide a more detailed discussion of the relatively small literature that has examined the cost of TBI. Most of this work has focused on civilian populations. An early study by Max, MacKenzie, and Rice (1991) estimates the lifetime cost of brain injuries sustained in 1985 at $37.8 billion, or $115,305 per injury. The cost components included in the estimate are medical services (12 percent of total), productivity losses (54 percent of total), and mortality (34 percent of total). The study includes only the costs for those injuries for which people were hospitalized or died. Because it does not include mild cases of TBI that do not require hospitalization, the Max MacKenzie, and Rice (1991) estimate should be viewed as conservative. More recent studies have updated the Max, MacKenzie, and Rice (1991) estimate with new data on the incidence of TBI and have adjusted costs to reflect medical inflation (Lewin-ICF, 1992; Thurman, 2001).

Miller et al. (1994) analyze fatalities, hospital admissions, and emergency department visits in national data collected between 1979 and 1989 to estimate the annual costs of TBI. While the estimate for the annual costs of medical care for TBI, $5.8 billion in 1992 dollars, is in line with estimates from Max, MacKenzie, and Rice (1991) when converted to constant dollars, the total cost estimate, $274.5 billion in 1992 dollars, is much higher because they include costs associated with a reduced quality of life. Miller et al. (1994) report that quality-of-life costs account for two-thirds of the cost of nonfatal injuries.

We identified one prior study that estimates the cost of deployment-related TBI. Wallsten and Kosec (2005) estimate the societal costs associated with the conflict in Iraq. Their comprehensive estimate includes the lifetime cost of treating TBI and the associated loss in quality of life. They estimate that 20 percent of all injured troops have sustained a severe head injury. Based on information from the National Association of State Head Injury Administrators, Wallsten and Kosec assume that the lifetime cost of treating a single case of TBI ranges from between $600,000 and $4 million. They calculate the loss in quality of life as the value of a statistical injury. That is, they infer the loss in quality of life by measuring what people are actually willing to pay to reduce the risk of certain types of injuries. In total, they estimate that the lifetime cost of TBI is $16 billion in 2005 dollars. It has been argued that the Wallsten and Kosec (2005) estimate is too high, largely due to their assumptions regarding the number of TBI cases and their level of severity. For example, CBO Director Peter Orszag, in congressional testimony before the House Committee on the Budget on October 24, 2007 (House of Representatives, 2007), stated that assuming that 20 percent of all injured troops experience severe brain injuries is grossly overstating the problem. He argues that, based on data from a DoD medical census, there had been 1,950 traumatic brain injuries through December 2006 and that about two-thirds of the diagnoses were for mild TBI as opposed to moderate or severe TBI.

None of the studies described here provided estimates that are directly comparable to those generated for this report. While the methodology that we employ is similar to that used by Max, MacKenzie, and Rice (1991), we focus on the costs incurred within a single year rather than the lifetime costs associated with those same injuries, which would cause our estimates to be smaller. We should also note that older studies, such as Max, MacKenzie, and Rice (1991), are less useful as a point of comparison because of the possible changes in medical technology and practice patterns. Moreover, Max, MacKenzie, and Rice (1991) describe the costs for a civilian population. The types of injuries observed may vary substantially from those observed in a military population. In that regard, Wallsten and Kosec (2005) provide the most comparable estimate because their estimate is based on TBI that occurred in combat in Iraq. However, there are some important differences in methods that should be noted. For example, they present lifetime costs as opposed to single-year costs. In addition, they use a different method to account for productivity losses that is based on people's willingness to pay to avoid an injury. Moreover, the willingness-to-pay methodology incorporates additional costs that we do not capture, such as quality of life. While their comprehensive estimate includes lives lost, it is not broken out by type of injury, and thus the TBI-related mortality costs cannot be broken out.

Data and Assumptions Regarding Deployment-Related TBI and Costs

In this section, we lay out the data and assumptions we have made to generate our estimate of the number of cases. However, given the uncertainty surrounding the prevalence of TBI, particularly the breakdown between mild and more severe cases, in the results section we present both a total cost and a per-case cost of TBI. The per-case cost can then be used to generate different total cost estimates for different assumptions regarding the number of TBI cases and level of severity (i.e., mild versus moderate/severe) among veterans returning from OEF and OIF.

The Number of TBI Cases in 2005. The estimate of the number of deployment-related TBI cases in 2005 is taken from the *Medical Surveillance Monthly Report* (MSMR) (2007, p. 30). The MSMR identifies TBI cases using diagnosis codes (ICD-9s) from inpatient and outpatient records. As such, people who are experiencing symptoms of TBI but who have not been formally diagnosed are not reflected in this count. Therefore, the prevalence estimates used for this analysis are substantially lower than those generated in the survey discussed in Chapter Four, which used self-reported symptoms to screen for probable TBI. The report does not distinguish between mild and moderate/severe cases. To generate separate estimates for mild and moderate/severe cases of TBI, we assume, based on the statement of CBO Director Orszag (House of Representatives, 2007), that two-thirds of cases are mild and the remaining one-third are moderate/severe. In addition, to reflect the fact that some moderate/severe cases of TBI that occurred prior to 2005 will still require treatment and potentially have negative outcomes associated with their injury in 2005, we use data from the MSMR (2007) to include one-third of TBI cases for 2004 (the moderate/severe cases) and one-ninth of TBI cases from 2003. Using one-ninth of the cases from 2003 assumes that one-third of the moderate/severe cases that occurred in 2003 still require treatment in 2005. We expect that this is a very conservative estimate, because many moderate/severe cases of TBI require rehabilitative treatment and incur productivity losses for longer than three years. However, we were unable to obtain any additional data on this issue and thus only made use of the MSMR data that went back to 2003.

Using this approach, we estimated a total of 609 TBI cases in 2005, with 279 being new mild cases, 139 being new moderate/severe cases, and 191 being remaining moderate/severe cases from 2003 and 2004 (Table 6.12).

The Cost of Treatment for TBI and TBI-Related Outcomes. We were unable to obtain any data on the cost of treating TBI in the military or the VA; therefore, all treatment cost estimates are based on civilian populations. Similarly, information on standard treatments used for deployment-related TBI and the duration of use of these treatments and/or rehabilitation are not available. Thus, when developing our estimates of rehabilitation costs and productivity losses, we rely on information available on civilian TBI patients. Specific information used for generating these costs estimates is discussed below.

Treatment for TBI. We estimated the cost of TBI for three categories of treatment: acute hospital care, inpatient rehabilitation, and outpatient rehabilitation. We know from

Table 6.12
Number of Deployment-Related TBI Cases

Type of TBI Case	Number of Cases[a]
Mild cases in 2005	279
Moderate/severe cases in 2005	139
Moderate/severe cases from 2003–2004 remaining in 2005	191
Total	609

[a] Calculations based on data from MSMR (2007).

the MSMR the number of TBI cases seen in a hospital setting versus seen on an outpatient basis. Using this information, combined with the assumption that one-third of all new TBI cases are moderate/severe, we can allocate injuries as shown in Table 6.13.

The MSMR (2007) reported that 332 known TBI cases presented in military hospitals in 2005. Given that there were only 418 new TBI cases in 2005 in total, the number of hospitalizations for TBI exceeds our estimate of the number of moderate/severe TBI cases (which we assumed is one-third of the 418 cases, which equals 139). Thus, to determine the number of mild and moderate/severe cases that require acute hospital care, we assumed that all moderate/severe cases were hospitalized and that any remaining hospitalizations come from the mild-TBI category.

The average cost of acute hospital care for TBI is obtained on HCUPNet, which tabulates data from the National Inpatient Sample (NIS) of the Healthcare Cost and Utilization Project (HCUP). The HCUP NIS is an inpatient care database that contains all discharge data from a sample of community hospitals. In 2005, the NIS included data from 1,054 hospitals located in 37 states. The NIS contains clinical and resource use information and can be weighted to produce national estimates. To estimate the average cost of acute hospital treatment for mild and moderate/severe cases of TBI, we tabulated average charges for various Diagnosis-Related Groups (DRGs). DRGs are used to classify hospital patients into groups expected to have similar resource use.

Table 6.13
Treatment for TBI and Associated per-Case Costs

	Number of Cases	Average Cost per Case	
		High	Low
Acute Hospital Care[a]			
Mild cases	193	$21,346	$15,144
Moderate/severe cases	139	$73,443	$28,747
Inpatient Rehabilitation[b]			
Mild cases	0	N/A	N/A
Moderate/severe cases	139	$14,007	$14,007
Outpatient Rehabilitation[c]			
Mild cases	279	$1,487	$618
Moderate/severe cases	139	$1,487	$618
Remaining moderate/severe cases from 2003–2004	191	$1,487	$618

NOTE: N/A = Not applicable.

[a] SOURCE: Average cost per case calculated from the National Inpatient Sample of the Healthcare Cost and Utilization Project 2005 data.

[b] SOURCE: Buntin et al. (2006).

[c] SOURCE: GAO (2004).

Using the DRGs allowed us to generate different hospital costs for moderate/severe and mild TBI cases. To represent moderate/severe cases, we tabulated the average charge for the DRG titled "Craniotomy with Complications and Comorbidities" in the high-cost scenario and the DRG titled "Traumatic Stupor and Coma >1 hour" for the low-cost scenario. For mild cases, the high-cost estimate was tabulated for the DRG titled "Concussion with Complications and Comorbidities" and the low-cost scenario is based on "Concussion without Complications and Comorbidities."

We were unable to find data on the proportion of TBI cases that require inpatient rehabilitation. We found a study conducted on a civilian population, however, that used the Colorado TBI Registry and Follow-up System and determined that 35 percent of patients hospitalized with TBI injuries are still functionally disabled one year post-injury (Brooks et al., 1997). In the absence of similar data specific to military personnel, we made the conservative assumption that only moderate/severe cases of TBI will require inpatient rehabilitation. The cost of inpatient rehabilitation was taken from a technical report produced by RAND titled *Inpatient Rehabilitation Facility [IRF] Care Use Before and After Implementation of the IRF Prospective Payment System* (Buntin et al., 2006). From this report, it was possible to generate an average episode reimbursement rate cost for TBI-specific injuries, although the report did not allow us to distinguish mild injuries from severe injuries. In other words, we could generate only an average episode cost across all TBI cases requiring inpatient rehabilitation services. We recognize that Medicare reimbursement rates may not be reflective of the actual value of resources used in the treatment of TBI, particularly among military patients.[13] However, in the absence of accurate information on rehabilitation services used by the military, the Medicare reimbursement rate represents a reasonable approximation of what these services could cost if treated in the civilian sector.

The data on the utilization of outpatient rehabilitation services were very thin. In fact, we were unable to find any information on the typical pattern of use, that is, the number and type of visits a TBI patient would be expected to receive. In the absence of solid data, we assumed that all identified TBI patients receive some outpatient rehabilitative services. The estimated cost per case is taken from a GAO report on comprehensive outpatient rehabilitation facilities (GAO, 2004) that compares the average Medicare payment for outpatient therapy across different provider types in Florida. We used the average per-patient cost for Rehabilitation Agencies for the high-cost scenario and for Hospital Outpatient Departments for the low-cost scenario. While there may

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[13] Under the Inpatient Rehabilitation Facility Prospective Payment System, Medicare pays facilities a predetermined rate per episode that varies by case mix group and geographic factors, such as local area costs and poverty rate. The case mix group is determined by the patient's age, impairment, functional status (motor and cognitive) at admission, and additional co-morbidities of the population served in these facilities. Hence, the mix of injuries may differ from those observed among military personnel, leading to a difference in average cost of rehabilitation services. Given that military injuries are likely to be even more severe than civilian injuries, we expect that this Medicare reimbursement rate will underestimate the true cost per episode.

be differences in the average cost of care across geographic regions that treat military personnel, we could not identify another source containing rate information. Thus, we relied on the Florida-specific Medicare estimates and recognize this as another limitation of the current study.

Mortality and Associated Costs. To estimate the number of TBI-related deaths in 2005 (excluding deaths by suicide), we used data from Ivins et al. (2006) that examined trends in hospital admissions associated with TBI and related deaths in the U.S. Army as well as information from HCUP NIS on the percentage of TBI cases (defined by ICD-9 diagnosis codes 800-804, 850-854, 959.01) that resulted in death in the hospital. Ivins et al. (2006) report that in 1990 the TBI death rate per 100,000 active duty personnel was 4.7 and declined to 2.5 by 1999, a 42.3-percent reduction. These are peacetime data, however, and may not reflect the death rate during the OEF and OIF conflicts if the severity of injury is higher. Using the rate of 2.5 deaths per 100,000 active duty personnel, we calculated that 9 percent of moderate/severe cases result in death. We used this as the high-cost scenario, but realize that it is likely still rather conservative. For the low-cost scenario, we used an estimate of the percentage of TBI hospitalizations that result in death from the HCUP NIS, 6.8 percent of hospital cases (HCUPnet, no date). Table 6.14 shows the total number of deaths included in our estimates.

As in the earlier model of PTSD and major depression, we used an estimate of the value of a statistical life employed by Wallsten and Kosec (2005). We inflated their estimate to 2005 dollars, yielding a value of $7,057,700.

Suicide and Associated Costs. As reported in Part III of this monograph, research also has consistently shown that persons with TBI have a higher risk of suicide than persons without TBI (e.g., Simpson and Tate, 2002, 2005; Hibbard et al., 1998; Teasdale and Engberg, 2001). However, none of these studies was able to conclusively show a causal relationship. Therefore, to estimate the number of suicide attempts and completions attributable to TBI in the high-cost scenario, we used estimates from Simpson and Tate (2002) showing that, among outpatients with TBI, 23 percent reported suicide ideation and 18 percent reported having had a suicide attempt post-injury. That is, we assumed that 18 percent of the moderate/severe TBI cases resulted in attempted

Table 6.14
Mortality from Deployment-Related TBI and the Value of a Statistical Life

	Number of Deaths		
	High	Low	Value of Statistical Life[a]
Mild cases	0	0	$7,057,700
Moderate/severe cases	13[b]	9[c]	$7,057,700

[a] SOURCE: Wallsten and Kosec (2005).

[b] SOURCE: Calculations based on Ivins et al. (2006).

[c] SOURCE: Calculations based on HCUP NIS (2005) data.

suicide. To determine the number of associated deaths, we used information from the *2006 Army Suicide Event Report* (U.S. Army, 2007) indicating that 8 percent of suicide attempts in the Army are successful. This calculation assumes that all post-TBI suicide attempts are caused by TBI, thus providing an upper bound. For the low-cost scenario, we assumed that none of the post-TBI suicide attempts is caused by TBI and therefore that the cost is not attributable to the condition.

To estimate the costs associated with suicide, we included the average medical cost for each attempt and the value of a statistical life when death occurs, as was done in the microsimulation model. The estimated cost of medical treatment for suicide attempts was taken from a recent article by Corso et al. (2007) showing the medical cost in 2000 dollars for a fatal suicide attempt ($2,596), a nonfatal hospitalized suicide attempt ($7,234), and a nonfatal, nonhospitalized suicide attempt ($1,139). We inflated the medical costs to 2005 dollars and used a weighted average cost of nonfatal attempts that are hospitalized (53 percent of cases) and nonhospitalized (47 percent of cases).[14] Assumptions regarding the number of suicide attempts, deaths, and associated costs are shown in Table 6.15.

Productivity Reductions and Associated Costs. TBI can influence productivity in two distinct ways. First, it can reduce employment, as patients deal with treatment and rehabilitation or adjust to new limitations caused by the injury. Second, it can reduce the amount of work that can be done while on the job, because of limitations caused by the injury. Our estimate of lost productivity attempts to measure productivity losses

Table 6.15
Suicide Attempts, Fatal Attempts, Associated Medical Costs, and the Value of a Statistical Life

Suicide Attempts	Number of Attempts[a]		Medical Costs per Attempt[b]	Value of Statistical Life[c]
	High	Low		
Nonfatal Attempts				
Mild cases	0	0	$4,937	N/A
Moderate/severe cases	25	0	$4,937	N/A
Fatal attempts				
Mild cases	0	0	$2,933	$7,057,700
Moderate/severe cases	2	0	$2,933	$7,057,700

NOTE: N/A = Not applicable.

[a] SOURCE: Calculations based on Simpson and Tate (2002).

[b] SOURCE: Corso et al. (2007).

[c] SOURCE: Wallsten and Kosec (2005).

[14] The weights are based on a personal communication with Ted Miller and unpublished data provided by Eduard Zaloshnja, Pacific Institute for Research and Evaluation, supporting Finkelstein, Corso, and Miller (2006).

associated with time unable to work and lower production when on the job. First, to capture reduced employment, we used information from a study by Boake et al. (2005) comparing the rate at which civilians return to work after experiencing a mild or moderate TBI with that of civilians experiencing a trauma not involving a head injury. Thus, the study attempts to isolate the effects of head trauma independent of other elements of trauma. The study follows patients treated with both injuries and assesses the number of people who are able to return to work at one month, three months, and six months post-injury. The results are presented by TBI severity and, in the case of mild TBI, those admitted to a hospital versus those treated in an emergency department and discharged. From these, the fraction of patients suffering from TBI who remain unable to work can be easily calculated. We used linear interpolation to construct rates of not working at months two, four, and five. We then combined information from this study with that reported by Salazar et al. (2000), who find that 90 percent of military personnel with moderate to severe closed head injury were employed one year post-injury. Using linear interpolation between this one-year mark and Boake et al.'s six-month estimate, we were able to fill in the rate of TBI-caused unemployment for each month in between. Table 6.16 shows the unemployment rates associated with TBI injury.

As noted above, the second way productivity might be affected by TBI is through reduced production by those who return to work with TBI. Wages are typically used as a measure of a worker's marginal productivity (or incremental production) on the job, because they represent what the firm is willing to pay the individual to work. To generate an estimate of reduced productivity on the job, we need information on the number of people who return to work with a serious disability caused by TBI and the extent to which this impacts their productivity. Very little evidence is available on which to base such an estimate. Johnstone, Mount, and Schopp (2003) found in one civilian population that average income among individuals with TBI was 48 percent lower one year after injury. And Brooks et al. (1997) suggest that 34 percent of hospitalized survivors of TBI injuries were still disabled one year after the injury.

Given the scarcity of information, particularly for the military population, we assumed that only individuals with a moderate/severe TBI injury were likely to expe-

Table 6.16
Unemployment Rates Associated with TBI Injury

	Percentage Unemployed at 1 Month[a]	Percentage Unemployed at 3 Months[a]	Percentage Unemployed at 6 Months[a]	Percentage Unemployed at 1 Year[b]
Mild TBI ED only	0.54	0.34	0.32	0.1
Mild TBI (hospitalized)	0.61	0.38	0.29	0.1
Moderate TBI (hospitalized)	0.85	0.65	0.6	0.1

[a] SOURCE: Boake et al. (2005)

[b] SOURCE: Salazar et al. (2000)

rience long-term disability severe enough to affect their income. Furthermore, we assumed that only those people who were unable to return to work after being off work for six months or longer would experience a reduction in pay, equivalent to a 48-percent annualized reduction.

Information on annual income converted to monthly income (by dividing by 12) was used to estimate the cost associated with lost productivity when considering both time spent not working and reduced productivity on the job. Because average income varies depending on the individual's military status, we obtained separate average-income figures for those in active duty and Reserve, and those who have left the military. The average income for reservists, $33,465, was taken from Wallsten and Kosec (2005), who calculate the average wage of reservists based on a weighted average of wages earned in civilian occupations by reservists in 2005. We took this average reservist income and added in Reserve personnel pay received from DoD, where Reserve personnel pay was calculated for an E-5 with 5 to 7 years of service. Based on these calculations, the average income for Reserve personnel was estimated to be $36,977. For active duty personnel, the average income, $61,460, was taken from the GAO Military Compensation Report (GAO, 2005) for 2004 and inflated to 2005 dollars. This compensation reflects cash compensation in the form of basic pay, housing allowances, and special incentives. For those who left the military in 2005 after returning from deployment, we used information on average income generated from full-time workers who are part of the 2005 National Compensation Survey (NCS), conducted by the Bureau of Labor Statistics (Department of Labor, 2006). According to the NCS, average annual income for 2005 was $39,629.

Estimates of the Cost of Deployment-Related TBI in 2005

Using the data and methods described above, we estimated the cost of deployment-related TBI to be between $90.6 and $135.4 million in 2005.

Table 6.17 presents the total and per-case cost estimates for 2005 overall and by injury severity for each cost category. As can be seen within and across cost categories, costs vary substantially by severity of injury. For mild TBI, the per-case cost for 2005 was estimated to be between $25,571 and $30,730. Because this estimate was built from diagnosed mild TBI, it likely reflects the cost of the more serious mild cases. Some cases of mild TBI go undiagnosed and untreated. These cases may incur some costs, but the costs will likely not be as high as those reported here. Since individuals who screen positively for probable TBI but who have not accessed the health care system or received a formal diagnosis may incur fewer costs, it would be inappropriate to apply these cost-per-case figures to the prevalence estimates for probable TBI discussed in Chapter Four. For moderate/severe cases, we estimated a range of $252,251 to $383,221.

In addition, we saw differences in the key cost drivers between mild and moderate/severe cases. For mild cases, Figure 6.6 shows that productivity losses account for 47

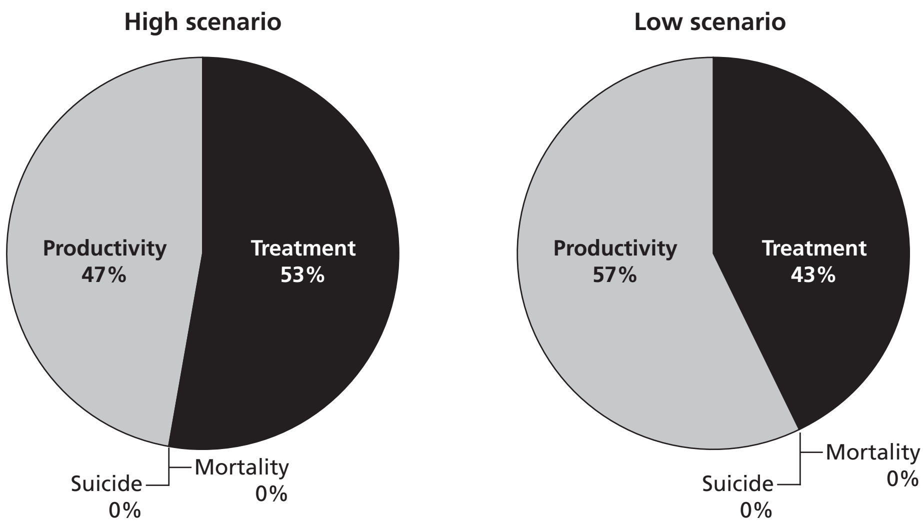
Table 6.17
Total and per-Case Costs of Deployment-Related TBI in 2005

	Overall		Mild		Moderate/Severe	
	High	Low	High	Low	High	Low
Treatment Costs						
Hospital acute care	$14,328,355	$6,918,625	$4,119,778	$2,922,792	$10,208,577	$3,995,833
Inpatient rehabilitation	$1,952,535	$1,952,535	0	0	$1,952,535	$1,952,535
Outpatient rehabilitation	$906,734	$376,941	$414,836	$172,453	$491,898	$204,489
Mortality Costs						
TBI-related deaths	$88,715,289	$66,709,380	0	0	$88,715,289	$66,709,380
Suicide Costs						
Deaths from suicide	$14,721,421	0	0	0	$14,721,421	0
Suicide attempts	$123,533	0	0	0	$123,533	0
Productivity Costs						
Unemployment (lost productivity)	$13,465,192	$13,465,192	$4,039,099	$4,039,099	$9,426,092	$9,426,092
Reduced wages for those working	$1,206,715	$1,206,715	0	0	$1,206,715	$1,206,715
Total cost of TBI	$135,419,773	$90,629,389	$8,573,713	$7,134,344	$126,846,060	$83,495,045
Total cost per case of TBI	$222,000	$148,573	$30,730	$25,571	$383,221	$252,251

percent to 57 percent and treatment accounts for 43 percent to 53 percent of total costs. Mortality and suicide costs are assumed to be zero for mild-TBI cases. For moderate/severe cases (Figure 6.7), mortality is the largest cost component, accounting for 70 percent to 80 percent of costs, while productivity losses account for 8 percent to 13 percent, treatment accounts for 7 percent to 10 percent, and suicide accounts for up to 12 percent of total costs.

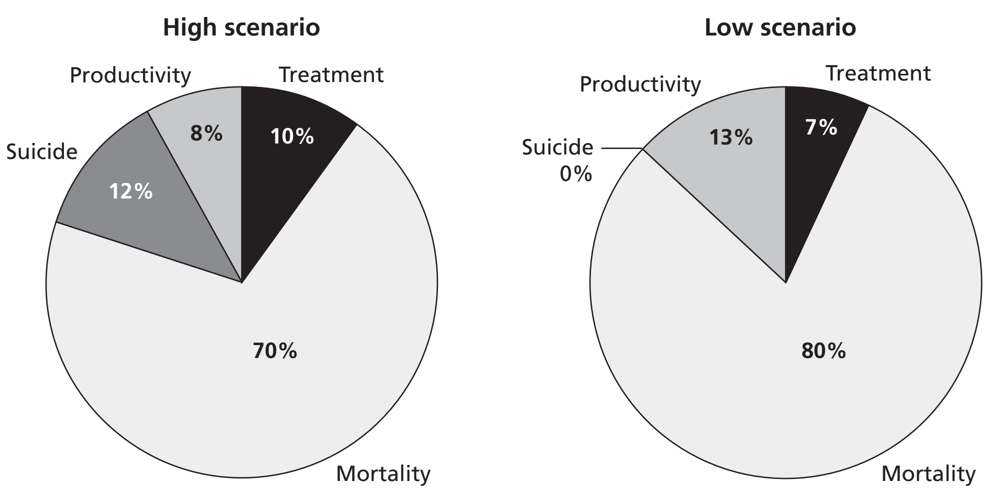
The estimates presented thus far represent the costs of deployment-related TBI cases in 2005. We used an adjusted per-case cost estimate for 2005 to generate a total cost of all deployment-related TBI cases identified since September 2001 (2,726) as reported in *Serve, Support, Simplify*, the report of the President's Commission on Care for America's Returning Wounded Warriors (2007, p. 2). We adjusted the 2005 per-case cost estimate by eliminating the residual moderate/severe TBI cases from prior years, so that the per-case cost just reflects the costs incurred in the first year post-injury. This is done primarily because we did not have good information on the timing of the 2,726 TBI cases or on the pattern of treatment and productivity losses beyond one year. From the testimony of CBO Director Orszag, we assumed that one-third of

Figure 6.6
Total Cost of Mild TBI, by Cost Component and High/Low Scenario



RAND *MG720-6.6*

Figure 6.7
Total Cost of Moderate/Severe TBI, by Cost Component and High/Low Scenario



RAND *MG720-6.7*

the total cases are moderate/severe and the remaining two-thirds are mild (House of Representatives, 2007). The estimates, shown in Table 6.18, indicate that total costs for TBI range between $554 million and $854 million, with moderate/severe cases accounting for approximately 92 percent of the total.

Several caveats regarding the total cost estimates must be considered. First, as noted above, the per-case cost includes only the costs incurred during the first year post-injury. For mild cases, this is probably reasonable. For moderate/severe cases, however, this is likely to understate the costs because it does not include the cost of treatment or any reduction in productivity that extends beyond the first year. Second, this estimate assumes that the per-case costs are constant over time; in reality, it is possible that medical technologies used to treat TBI changed over time, which would have an effect on costs. However, because we are considering a relatively short time frame (2001 through 2007), the effect of this assumption on the overall estimate is mitigated.

Limitations

A number of important caveats are associated with our general estimation strategy that should be noted. First and foremost, the estimates are imprecise because we did not have access to high-quality data on which to formulate many of the inputs in this calculation. Most findings were drawn from studies or cost information related to civilian patients, who likely experience very different types of TBI that could require very different treatment resources. Furthermore, the cost of those resources might differ for civilian versus military populations. Given the scarcity of reliable information related to the prevalence, treatment, and costs of TBI in the military, such assumptions are necessary. They clearly, however, introduce a conservative bias into the overall estimate that needs to be kept in mind when discussing the final cost estimates.

A second limitation is that the estimate is not comprehensive because we were unable to include a number of important cost categories, such as caregiver burden, substance abuse co-morbidity, TBI-related health problems, violence, and family functioning owing to a lack of data. Finally, our estimates include only costs incurred in a given year. Many of the effects and associated costs of TBI, particularly for those with moderate/severe injuries, will continue in the long term. We attempted to address this to

Table 6.18
Total Cost of Deployment-Related TBI

	Mild		Moderate/Severe		Total	
	High	Low	High	Low	High	Low
Number of cases	1,800	1,800	926	926	2,726	2,726
Per-case cost	$30,730	$25,571	$862,621	$549,183	$313,317	$203,438
Total	$55,314,277	$46,028,025	$798,786,794	$508,543,345	$854,101,071	$554,571,370

some extent by including a fraction of moderate/severe cases that occurred in 2003 and 2004 in the 2005 estimate. However, we expect that this is insufficient to capture the full costs of TBI in 2005. There are probably people who experienced a TBI between 2001 and 2003 who are still receiving treatment and who are incurring productivity losses. Therefore, our estimate, even the high scenario, is likely conservative.

Discussion

Despite these limitations, we believe that the estimates presented here provide useful information to policymakers regarding the costs associated with deployment-related TBI. The estimates show that the costs are substantial and are driven primarily by the loss of life and loss of productivity associated with TBI, rather than the treatment costs. The productivity losses could be mitigated by improving access to high-quality treatment for TBI. Rehabilitative services designed to help individuals increase functionality and return to work could increase employment and income among those employed.

A particularly striking result of this analysis is the fact that costs associated with mild TBI are an order of magnitude lower that costs associated with moderate or severe TBI. Based on our review of the evidence, we have little reason to believe that mild TBI would be associated with mortality—a large driver of costs for severe and moderate TBI. Moreover, mild TBI may not require inpatient rehabilitation. Given these very large differences in both costs and mortality outcomes, this analysis raises the question of whether it makes sense to group mild TBI with moderate and severe TBI when making policy decisions about how to care for injured servicemembers.

Conclusion

The costs associated with mental and cognitive conditions stemming from the conflicts in Afghanistan and Iraq are substantial. On a per-case basis, two-year post-deployment costs associated with PTSD are approximately $5,904 to $10,298, two-year post-deployment costs associated with major depression are approximately $15,461 to $25,757, and two-year post-deployment costs associated with co-morbid PTSD and major depression are approximately $12,427 to $16,884 (at 2007 price levels). These costs vary depending on whether or not we include the value of lives lost to suicide in our estimates; because suicide is a rare and uncertain event, cost estimates that exclude suicide-related mortality costs are more precise.

Annual costs associated with traumatic brain injury are even higher, ranging from $25,571 to $30,730 per case for mild cases in 2005 (or $27,259 to $32,759 at 2007 price levels[15]) and from $252,251 to $383,221 for moderate/severe cases in 2005 ($268,903

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[15] We converted 2005 costs to 2007 levels using the July Consumer Price Index (CPI; the annual CPI for 2007 was not available as of this writing). The specific conversion ratio that we used is: 208.3/195.4 = 1.07.

to $408,519 at 2007 price levels). These estimates include treatment costs and costs associated with suicide, lost productivity, and death. However, our cost figures omit downstream costs stemming from substance abuse, domestic violence, homelessness, family strain, and several other factors. We also did not consider costs associated with implementing evidence-based treatment on a large scale (e.g., outreach, provider training) or spillover costs that might stem from increased contact with the health care system among veterans in need of mental health care.

Translating these cost estimates into a total dollar figure is challenging because there is uncertainty about the total number of cases in a given year, as well as the severity of those cases and the extent of co-morbidity among the three conditions. Despite these caveats, we estimated that the total cost of TBI in 2005 ranged from $90.6 to $135.4 million in 2005, which is equivalent to $96.6 to $144.4 million at 2007 prices. We applied an adjusted per-case cost to the total number of deployment-related TBI cases to generate an estimate of the total one-year post-deployment costs, which range between $591 and $910 million (2007 dollars). Within the first two years after returning from deployment, we estimate that costs associated with PTSD and major depression for 1.6 million servicemembers could range from $4.0 to $6.2 billion, depending on whether we include the costs of lives lost to suicide. These costs are for the number of servicemembers deployed since 2001 and the total number of TBI cases identified as of June 2007. Because total cost estimates are based on historical deployments and identified TBIs, most of the costs included in these estimates have already been incurred. However, since the conflicts in Afghanistan and Iraq are ongoing and the consequences of psychological and cognitive injuries may last for many years post-deployment, these figures are an underestimate of the total costs that will be incurred in the future.

Our results also suggest that lost productivity can be a large driver of costs. For PTSD and major depression, 55.3 to 94.5 percent of total costs can be attributed to reduced productivity; for mild TBI, productivity losses may account for between 47 and 57 percent of total costs. VA disability payments are intended to compensate veterans with Service-connected disabilities for reduced wages; as a result, these high productivity losses could potentially become the responsibility of the VA. Because severe TBI can lead to death, mortality is the largest component of cost for moderate to severe TBI, accounting for 70 to 80 percent of total costs.

The microsimulation model that we developed for PTSD and major depression suggested that there are potential cost savings associated with evidence-based treatment within the first two years after a servicemember returns to the United States, even without accounting for downstream costs stemming from substance abuse, homelessness, and other factors. In our estimates that include the cost of lives lost to suicide, we predict that evidence-based treatment for PTSD and major depression could save as much as $1.7 billion within two years post-deployment, or $1,063 per returning veteran. These cost savings come from increases in productivity, as well as reductions in the expected number of suicides. The benefits of evidence-based treatment are most pronounced for major depression; the benefits of evidence-based treatment for PTSD and co-morbid PTSD and major depression are sensitive to whether or not we include the value of lives lost to suicide in our cost estimates.

These findings lead to several recommendations regarding caring for veterans, as well as for understanding the costs associated with war-related psychological and cognitive injuries. First, cost studies that do not account for reduced productivity may significantly understate the true costs of the conflicts in Afghanistan and Iraq. Currently, there is limited information on how mental health conditions affect career outcomes within DoD. Given the large association between mental health status and productivity found in civilian studies, research that explores how active duty personnel's mental health status affects career outcomes would be valuable. Ideally, studies would consider how mental health conditions influence job performance, promotion within DoD, and transitions from DoD into the civilian labor force. In this chapter, we used data from civilian studies to estimate the relationship between a mental health condition and productivity among active duty personnel—in the absence of other information, these estimates are valuable. However, they could be improved upon with better data.

If our estimates of productivity loss are appropriate for the active duty population, our findings suggest that—from a societal perspective—evidence-based treatment for PTSD and major depression would pay for itself within two years. Given these results, investments in evidence-based treatment might make sense from DoD's standpoint not only because of higher remission and recovery rates but also because it would increase productivity of servicemembers. Hoge, Auchterlonie, and Milliken (2006) show that retention within DoD is higher among those without a deployment-related mental health condition. More generally, to the extent that DoD and the VA demonstrate a commitment to providing injured servicemembers the most effective care, as well as minimizing costs that accrue to disabled servicemembers, retention and recruitment might be improved. Increased productivity among servicemembers who have separated from DoD might also be a policy goal because higher productivity reduces the need for disability payments, which are intended to offset lower earnings among servicemembers who have a reduced ability to work because of a Service-connected disability. Finally, as a society, we may benefit by investing in evidence-based treatment for returning servicemembers, not only because it is our responsibility to provide these individuals with effective treatment but also because doing so may reduce downstream costs stemming from unemployment, need for disability payments, and public assistance. Had we been able to account for omitted cost components—such as substance abuse, domestic violence, and homelessness—the savings to society would likely be even greater.

Appendix 6.A: Model Map

NOTE: r^* denotes a random number that is drawn separately for each bullet. *Day 1* refers to the first day home following deployment.

1. Create synthetic cohort.

- Determine the number of individuals returning from OIF/OEF.
- Assign age, gender, race, education, branch, reserve status, rank, and civilian labor force status (if individuals leave full-time active duty; based on March 2007 Current Population Survey).
- Reservists immediately transition to nonmilitary civilian status on Day 1.

2. Assign mental health status at return.

- To reduce computing time, we ran a simulation with a relatively high number of individuals with mental health conditions and then weighted costs to reflect prevalence estimates derived from the literature (15 percent of all individuals get PTSD within two years, 50 percent of all PTSD is co-morbid with depression, and 7.2 percent of individuals get depression alone).
- Randomly assign 60 percent of the sample to PTSD; 20 percent will have PTSD on Day 1 and 40 percent will have PTSD onset during the simulation (the quarter for delayed-onset PTSD is determined randomly).
- 50 percent of those with PTSD will also have co-morbid depression (if it is delayed-onset PTSD/depression, the depression will be delayed, too).
- Randomly assign depression alone to 75 percent of the sample that will not have PTSD during the simulation.

3. Allow instantaneous attrition for full-time active duty.

- If $r^* \leq A^*$, individual leaves military on Day 1.
- A^* is based on Hoge, Auchterlonie, and Milliken (2006) and depends on mental health status.
- Individuals who leave the military at this point do not enter the Reserves.

The remaining sections of this model map describe what happens in every quarter (Q). The simulation used for this monograph is based on two years ($Q_1 - Q_8$).

4. Did the individual attempt suicide in Q_t?

- If individual has a mental health condition and $r^* \leq S^*$, he or she attempts suicide.
- S^* is based on Gibbons et al. (2007) and varies by age.

- Because attempt probabilities are annual and the model is updated quarterly, we randomly chose the quarter when a suicide attempt can occur.

5. Did the individual complete suicide in Q_t?

- If individual attempts suicide and *r**≤F*, the suicide attempt is fatal.
- F* varies by military status. (F* equals 8.6 percent for active duty personnel and 4 percent for non–active duty or discharged personnel; various sources.)
- Suicide is the only way someone can die in the model.

6. What was the individual's civilian labor force status (CLFS) during Q_t?

- Irrelevant if full-time military, because we assume no moonlighting.
- Initial CLFS (full, part, or unemployed) is based on distribution of veterans in the 2007 CPS.
- CLFS can change only when an individual experiences a change in mental health status. These probabilities are based on Savoca and Rosenheck (2000).

7. How much did the individual earn in Q_t?

- Military pay for active duty servicemembers and reservists is taken from official military pay tables (depends on rank and years of service).
- Full-time military personnel also receive a subsistence allowance (depends on rank) and a housing allowance (depends on number of dependents; we use a weighted average).
- Civilian wages for non–active duty and discharged servicemembers come from wage regressions based on veterans in the 2006 CPS. Predictors include age, gender, race/ethnicity, education, and marital status (this last variable is not tracked in the simulation, and we impute the sample average).
- We ran separate regressions for full- and part-time workers.
- Those who are unemployed were assigned a wage = 0.
- For individuals with a mental health condition, wages were decremented based on rates reported in Savoca and Rosenheck (2000).
- Wages in quarter of fatal suicide (and in subsequent quarters) = 0.

8. Did the individual enter mental health treatment in Q_t?

- To reduce computing time, we ran a simulation with a relatively high number of individuals entering treatment and then weighted costs to reflect estimates derived from the literature.
- If individual has a mental health condition and *r1**≤0.66, the individual receives treatment.

- If individual receives treatment and $r2^*\leq0.50$, the individual receives evidence-based treatment instead of usual care.
- In our status quo estimates, we re-weighted so that 30 percent of individuals with mental health conditions receive treatment and 30 percent of treatment is evidence-based.
- If treatment in Q_t has an effect, we assumed that we would not see that effect until the beginning of $Q_{t+1.}$
- If treatment in Q_t is unsuccessful, the individual has an 80 percent chance of continuing the same course of treatment in $Q_{t+1.}$
- Individuals cannot switch between evidence-based treatment and usual care.

9. Did the individual leave full-time active duty at the end of Q_t?

- If $r1^*\geq A^*$, individual leaves DoD.
- A* is based on data reported by Hoge, Auchterlonie, and Milliken (2006), and it varies depending on mental health status and length of time since returning home.
- Attrition only occurs at the end of a quarter.
- If individual has a nonfatal suicide attempt and $r2^*\leq0.80$, the individual leaves military.

10. Did the individual leave full-time active duty and enter the Reserves at the end of Q_t?

- If individual leaves DoD and $r^*\leq R^*$, individual joins the Reserves.
- R* varies depending on rank and branch.
- Individuals leaving because of suicide attempt do not enter the Reserves.

11. Was individual promoted to a higher rank at the beginning of Q_{t+1}?

- This is not a function of mental health.
- Everyone in the military is eligible for a promotion.
- If $r^*\leq P^*$, individual is promoted.
- *P** is based on the *Defense Manpower Requirements Report* (Department of Defense, OUSD, 2007) and varies depending on rank and branch.
- Because promotion probabilities are annual and model is updated quarterly, the quarter of promotion consideration is randomly assigned across the year.
- Individuals can be promoted only once during the simulation.

12. What was the individual's mental health status at the beginning of Q_{t+1}?

- Depends on whether treatment was received in Q_t, the effectiveness of that treatment, and the natural course of the disorder (remission, delayed-onset, and relapse).
- If $r1^* \leq T^*$, person remits.
- T* varies with treatment and type of mental health condition.
- If $r2^* \leq E^*$, then person relapses.
- *E** varies with illness, and in some specifications, with treatment.
- Because relapse probabilities are biennial and model is updated quarterly, the quarter of relapse consideration is randomly assigned across a two-year period after the illness remits. In some cases, the quarter of relapse consideration is greater than eight; thus, the individual does not relapse during the simulations.
- If quarter of delayed-onset PTSD or PTSD/depression = t, illness begins at the beginning of Q_{t+1}.

Appendix 6.B: Model Architecture, Assumptions, and Parameters

Model Dynamics

Our model has a two-year time horizon, and the information in the model is updated quarterly. At the beginning of the model, each individual is assigned a mental health status and probability of getting evidence-based or usual care conditional on mental health. Modeled individuals are then assigned an employment status (active duty, employed full-time or part-time in the civilian sector, or not employed), a wage rate conditional on employment, a probability of having a suicide attempt, and a probability of death conditional on a suicide attempt. We assumed that all servicemembers of the Reserve Component immediately return to civilian status when they return from OEF or OIF (this is the entry point into the model). Mental health status affects employment, treatment entry (only individuals with mental health conditions may enter treatment), and suicide-related outcomes. Mental health treatment affects the probability of recovering from a mental health condition, and—in some scenarios—the probability of relapse.

At each quarter, individuals make transitions across mental health status, treatment status, and employment status. Lower employment probabilities, wage reductions, suicide risks, and an increased probability of military attrition were assigned to individuals who suffer from a mental health condition.

Modeled Individuals

We populated our model using a cohort of "synthetic" individuals who have returned from deployment to Iraq or Afghanistan at the rank of E-5.[1] These individuals were assigned race/ethnicity, gender, educational attainment, component status (Reserve/Guard or active duty), and military branch (Army, Navy, Air Force, or Marine Corps). Gender, component, and branch assignments were based on data on servicemembers completing OIF deployments in 2005 (*Medical Surveillance Monthly Report*, 2007). Education levels for E-5s were based on data reported by the Congressional Budget Office (2004) and the Defense Manpower Data Center (2000); race/ethnicity assignments were based on the racial and ethnic distribution of all enlistees in 2005 (DoD, OUSDPR, 2005). Because we did not have access to data describing the joint distribution of age, rank, and years of service among returning veterans, we made the simplifying assumption that everyone in our synthetic cohort is a 25-year-old enlistee with 5 to 7 years of service, returning from

1 This is likely an underestimate of the number of E-5s returning from OIF or OEF in 2005. If we assume that 50 percent of the E-5s or E-6s completing OIF deployments in 2005 were E-5s, we get over 52,000 troops from all four branches for OIF alone (*Medical Surveillance Monthly Report*, 2007).

the conflict at a rank of E-5.[2] In sensitivity analyses, we considered alternative combinations of age, rank, and years of service, including officer-level ranks.

States. The model contains 31 states defined by employment status, mental health status, mental health treatment status, and suicide-related death. Figure 6.B.1 illustrates the states in the model, with arrows indicating possible transitions across states.[3] A *mental health condition* can be any one of three conditions: PTSD, major depression, or co-morbid PTSD/major depression. As a simplifying assumption, we constrained individuals from switching across conditions. This implies that, while some individuals in our model have a single mental health condition and some have co-morbid mental health conditions, no one with a single condition will ever develop co-morbid conditions, and no one with co-morbid conditions will ever recover from one co-morbidity but not the other.

Mental Health Status Assignments. An individual's initial assignment into a mental health state is based on prevalence data reported in Hoge et al. (2004) and Grieger et al. (2006). We assumed that, immediately after returning from OEF/OIF, 5 percent of the sample has PTSD and 7 percent of the sample has major depression alone. Delayed-onset PTSD can develop at any time during our two-year time horizon, such that an additional 10 percent of the sample will develop PTSD during the two-year period considered in the model. This rate of growth in PTSD over time corresponds to growth rates reported in Wolfe et al. (1999) in an 18-to-24-month analysis of PTSD among veterans of the first Gulf War. In addition, the rate is roughly consistent with Milliken, Auchterlonie, and Hoge (2006), who report that 6 percent of Army soldiers meeting screening criteria for PTSD immediately after return from OIF, with an additional 8 percent meeting screening criteria at a median of six months later. Our model assumptions also imply that 50 percent of individuals with PTSD develop the condition after six months, a figure that is consistent with rates of delayed-onset PTSD among military populations reported by Andrews et al. (2007).[4]

From figures reported in Grieger et al. (2006), we assumed that 50 percent of individuals with PTSD also have co-morbid major depression. Because mental health outcomes in our model are assigned stochastically, realized rates of mental health conditions will be variable. However, the model is designed so that, on average, 7 percent

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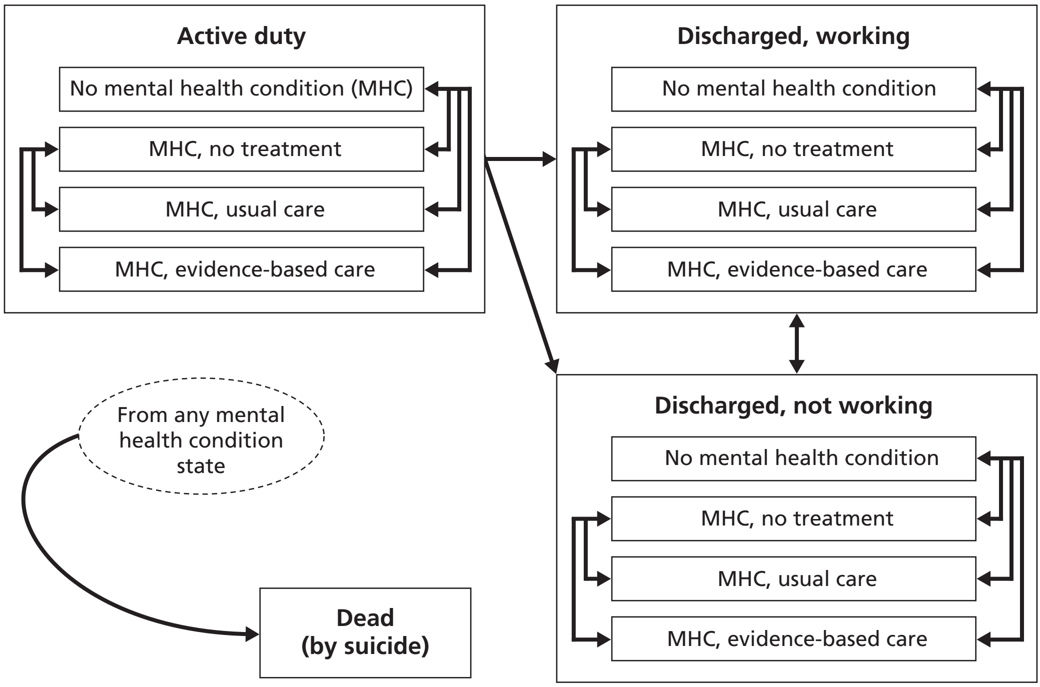
2 Age, rank, and years of service are highly interrelated, and all three of these characteristics have a large bearing on wage outcomes—a key element of cost in our model. Given the lack of available data, we felt that it would be inappropriate to use assumptions to jointly impute these characteristics, since inaccuracies in our imputation process could have a large effect on projected costs.

3 For ease of presentation, Figure 6.B.1 illustrates only a single, generic mental health condition. The states in the full model consist of 3 employment states times 1 non-illness state (=3), plus 3 employment states times 3 mental health condition states times 3 mental health conditions (=27), plus death, for a total of 31 states.

4 Andrews et al. (2007) report that, in a sample of six studies of military populations, the weighted average proportion of PTSD cases with delayed onset of six months was 38 percent. Three of the six studies reported delayed-onset rates of 50 percent or higher (and a fourth reported a delayed onset rate of 49 percent).

Figure 6.B.1
Model Dynamics



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of the sample will experience at least one bout of major depression, 7.5 percent of the sample will experience at least one bout of PTSD, and 7.5 percent of the sample will experience at least one bout of co-morbid PTSD and major depression during the two-year projection interval.

Mental Health Treatment and Treatment Assignments. Evidence-based therapies, described in Table 6.B.1, are based on published guidance, recent randomized controlled trials showing effectiveness, and the 2007 Institute of Medicine report on evidence-based treatment for PTSD. Because guidance for major depression varies depending on the severity of the illness and the patient's response to therapies, we allowed three potential treatment regimes among those getting evidence-based care for major depression. Specifically, 37.5 of individuals receiving evidence-based care for major depression will get regime 1 (drugs only), 37.5 will get regime 2 (psychotherapy only), and 25 percent will get regime 3 (combined therapy). We assumed that individuals receiving combined therapy, as well as individuals receiving evidence-based treatment for co-morbid PTSD/major depression, will take maintenance medication for a one-year period should their symptoms remit following an episode of treatment.

Usual care for PTSD and major depression, shown in Table 6.B.2, reflects the fact that it is common for individuals with mental health conditions to receive suboptimal

Table 6.B.1
Evidence-Based Treatment for PTSD and Major Depression

Condition	Medication over 12 Weeks	Psychotherapy over 12 Weeks	Maintenance Medication Required?	Source(s)
PTSD only	Daily SSRI	Ten 75–80-minute sessions of psychotherapy	No	Foa, Davidson, and Frances (1999), Institute of Medicine (2007); Schnurr et al. (2007)
Major depression only				
Regime 1	Daily SSRI	None	No	Keller et al. (2000), Friedman and Detweiler-Bedell (2004), De Maat et al. (2006), Pampallona and Bollini (2004), Ludman et al. (2007), Whooley and Simon (2000)
Regime 2	None	Ten 45–50-minute sessions of psychotherapy	No	
Regime 3	Daily SSRI	Ten 45–50-minute sessions of psychotherapy	Yes	
Co-morbid PTSD/ major depression	Daily SSRI	Ten 75–80-minute sessions of psychotherapy	Yes	Foa, Davidson, and Frances (1999)

NOTE: SSRI = selective serotonin reuptake inhibitor

Table 6.B.2
Usual Care for PTSD and Major Depression

Condition	Medication over 12 Weeks	Psychotherapy over 12 Weeks	Maintenance Medication Required?	Source(s)
PTSD, co-morbid PTSD/ major depression	32% get daily SSRI, 48% get daily SSRI for 1 month	3.2 50-minute sessions	No	Rosenheck and Fontana (2007), Simon et al. (2004)
Major depression only	26% get an SSRI; of these, 60% get the recommended dose and 40% discontinue after 1 month	100% get 1 visit with a PCP; 15% get a visit with a mental health specialist; 38% get 2 30-minute sessions of counseling	No	Young et al. (2001), Simon et al. (2004)

NOTE: SSRI = selective serotonin reuptake inhibitor; PCP = primary care provider

levels of medication and psychotherapy. In the absence of comprehensive information on usual care for veterans with co-morbid PTSD and major depression, we assume that these individuals get the same treatment as individuals with PTSD only.

Employment Assignments. We assumed that individuals in the Reserve Component convert immediately to civilian status on returning from OEF/OIF, and that those in the Active Component remain active for at least three months following their return home (unless they commit suicide). Those who return to civilian status are assigned employment probabilities (working full-time, working part-time, or not working) based on employment probabilities observed among veterans of a similar age range in the 2007 Current Population Survey. Conceivably, individuals who leave DoD may be unemployed for several months before finding a job in the civilian sector. Because we did not have data on employment during this transitional period, we made the assumption that employment probabilities are similar to the employment outcomes found in the CPS veteran population.

Cohort Used for Model Runs. Based on figures reported in the *Medical Surveillance Monthly Report* (2007), we determined that there were approximately 50,000 E-5s who returned from OIF in 2005. We initially populated our model with a cohort of 50,000 individuals to represent the actual number of E-5s returning from deployment. However, it took several hours for our model to run, and we still had a very small number of individuals receiving evidence-based treatment, causing model results to be volatile. To address this problem, we reduced the model cohort to 20,000 but allowed an equal number of people to experience each possible mental health and treatment combination. We then estimated costs for a cohort of 50,000 people by re-weighting the costs in each model cell to reflect the expected number of people in each group.

State Transitions. Individuals in the model can move across states, as described by the arrows in Figure 6.B.1. State transitions in the model include transitions out of the military, transitions into and out of the civilian labor force, remission and relapse following a mental health condition, transitions into and out of mental health treatment, and death via suicide. Each of these is described in more detail below.

Transitions out of the Military. Attrition from the military is based on rates reported by Hoge, Auchterlonie, and Milliken (2006), who found that soldiers and marines returning from OEF/OIF who meet screening criteria for mental health risk have greater attrition from DoD than those without mental health risk.[5] Specifically, within one year of return, 21 percent of those with a mental health condition had left the Service, versus 16 percent of those without. Because the study does not report separate attrition rates by type of mental health condition, we assumed that attrition is the same regardless of condition.

Among those who leave the Active Component, we assumed that a certain percentage will join the Reserves. Given the statistics provided by the Army Human Resources Policy Directorate (also known as the Army G-1), we assumed that 21 percent of enlisted soldiers and 15 percent of Army officers join the Reserves immediately after leaving the active duty force. Although we could not find data to validate Reserve transition rates for the other branches of the Services, we communicated with several DoD researchers who believed that transition rates were substantially lower for the Navy, Air Force, and Marine Corps. We therefore assumed that, among servicemembers leaving the Active Component of the Navy, Air Force, or Marine Corps, 11 percent of enlisted personnel and 5 percent of officers directly transition into the Reserves.

[5] *Mental health risk* in Hoge, Auchterlonie, and Milliken (2006) is based on a positive response to any of the mental health items included in the Post-Deployment Health Assessment (PDHA), including a modified version of the two-item Patient Health Questionnaire (PHQ-2) and a four-item PTSD screener.

In addition to their civilian wages, reservists are assigned a drill pay to reflect compensation for military service.[6] Since we did not have any data on the relationship between a mental health condition and the probability of joining the Reserves, we assumed that a mental health condition has no influence on the probability of joining the Reserves. This assumption is likely to be conservative, given that the civilian studies have found that a mental health condition can substantially reduce the probability of employment (Ettner, Frank, and Kessler, 1997; Stewart et al., 2003; Wang et al., 2007).

Transitions into and out of the Civilian Labor Force. Those who have left the military have a probability of joining the civilian labor force as either a full-time or a part-time worker, based on probabilities observed among veterans in the 2007 CPS. When a person has an active mental health condition, we reduced the probability of employment using figures reported by Savoca and Rosenheck (2000).[7] Specifically, relative to baseline probabilities reported in the CPS, those with PTSD are 8.6 percentage points less likely to be currently working, and those with major depression or co-morbid PTSD and major depression are 7.0 percentage points less likely to be currently working. We did not allow labor force participation to have an influence on mental health status.

Remission and Relapse Following a Mental Health Condition. All individuals in our model have a probability of experiencing remission following the onset of the mental health condition. Individuals receiving treatment have a higher probability of remission than those not receiving treatment, and individuals with evidence-based care have a higher probability of remission than those with usual care. Table 6.B.3 shows the probability of remission following an episode of treatment for each illness and type of care.

Conditional on recovery, individuals in our model also have a probability of relapse. Among those with PTSD or co-morbid major depression and PTSD, 55 percent of those receiving any treatment will relapse within two years, based on rates reported in Perconte, Griger, and Bellucci (1989). Because few studies have examined relapse among veterans who have recovered from PTSD, and because the sample in Perconte, Griger, and Bellucci (1989) may have had unusually severe symptoms, our lower-bound cost estimate reduces this relapse rate to 25 percent over two years. Although it is plausible that individuals who received evidence-based treatment might have lower rates of relapse than individuals who received usual care or no care, we did not have any data to confirm this hypothesis or to quantify the magnitude of the dif-

6 Drill pay information came from Department of Defense, "Reserve Drill Pay," Web page, no date-b.

7 Dohrenwend et al. (2006) argue that the data set that Savoca and Rosenheck use (the National Survey of the Vietnam Generation) overestimates PTSD. If anything, we expected this would bias downward the relationship between PTSD and labor force outcomes, since respondents flagged as having PTSD will include some individuals without a mental health condition.

Table 6.B.3
Remission Probabilities Following Three Months of Illness

	Treatment Assignment			
Condition(s)	**Evidence-Based Treatment**	**Usual Care**	**No Care**	**Sources**
PTSD, co-morbid PTSD and major depression	39%	30%	~5%[a]	Schnurr et al. (2007) Kessler et al. (1995) Wolfe et al. (1999)
Major depression alone	48%	40%	12%	Keller et al. (2000) Dimidjian et al. (2006) Ludman et al. (2007) Wells et al. (1992) Kocsis et al. (1988)

[a] Remission rates were derived from Wolfe et al. (1999).

ferential. As a result, we assumed that the probability of relapse is constant, regardless of treatment condition.

The baseline relapse rate for major depression is 54 percent over two years, based on a meta-analysis of 28 studies of relapse following major depression treated successfully with cognitive-behavioral therapy (Vittengl et al., 2007). While the average two-year relapse rate found in this analysis was 54 percent, the range varied between 15 and 85 percent. Moreover, the 54-percent figure does not include relapse rates for usual care or no care. Melfi et al. (1998) found that patients treated for major depression with at least four prescriptions of an antidepressant had lower relapse rates over 18 months than patients who discontinued treatment early. However, the proportion of patients experiencing relapse in this study (approximately 26 percent in the continuous-treatment group and 36 percent in the discontinued-treatment group) was far lower than the average rate reported in Vittengl et al. (2007). As a result, we used the Melfi et al. (1998) figures for our lower-bound cost estimate. For our upper-bound relapse estimate, we inflated the 54-percent baseline figure by 38 percent to get a predicted two-year relapse rate of 75 percent for individuals with usual care or no care. The 38-percent inflation rate comes from the relative increase in relapse for those who discontinued care in Melfi et al. (1998) (i.e., (36/26) = 1.38).

Transitions into and out of Mental Health Treatment. The probability of receiving treatment conditional on having a mental health condition is a key policy parameter in our model. As discussed in Chapter Five, rates of evidence-based care are relatively low in the civilian population, and rates may be even lower among veterans returning from OEF and OIF. In our “status quo” scenario, we assumed that 30 percent of veterans with a mental health condition receive any care and that 30 percent of these individuals (9 percent of those who are sick) receive usual care. We then altered these probabilities to evaluate the potential for cost savings if a larger share of individuals received any treatment and if a larger share of individuals received evidence-based treatment.

We assumed that those who have an unsuccessful treatment episode (i.e., they are still sick after 90 days of treatment) have an 80-percent chance of continuing treatment in the next quarter, regardless of whether they received evidence-based or usual care.

Suicide Attempts, Suicide Completions, and Death. The probability of a suicide attempt comes from Gibbons et al. (2007), who report attempted suicide rates for depressed veterans by age group.[8] A recent study (Zivin et al., 2007) finds that depressed veterans with PTSD have a lower probability of suicide than depressed veterans without PTSD. Our baseline estimates use the age-specific attempted suicide rates reported by Gibbons et al. (2007) for all three mental health conditions—for veterans between the ages of 18 and 25 with a mental disorder, the annual probability of a suicide is 1.1 percent. In our lower-bound scenario, we discounted this rate by a factor of 0.75 for individuals with PTSD or co-morbid PTSD and major depression, based on the relative differences in suicide probabilities found in Zivin et al. (2007).[9]

Conditional on attempting suicide, the probability of death is 8.6 percent, the rate reported in the *2006 Army Suicide Event Report* (U.S. Army, 2007). For individuals who have been discharged from DoD, we assumed that the success rate conditional on an attempt is 4.0 percent (Goldsmith et al., 2002).

We assumed that 80 percent of active duty personnel who have a suicide attempt will leave the military within 90 days. This assumption stems from conversations with DoD personnel suggesting a low command tolerance for retaining individuals who have attempted suicide, as well as a study (Hoge et al., 2002) finding high rates of attrition for servicemembers hospitalized for mental health conditions. We further assumed that individuals discharged for attempting suicide will not join the Reserves.

DoD Promotion Probabilities. Individuals on active duty have a probability of being promoted in each quarter, based on promotion rates observed in the 2007 *Defense Manpower Requirements Report* (DoD OUSDPR, 2006). Tracking promotions within DoD is important because wage is almost completely determined by an individual's rank. Because the transitions in the *Defense Manpower Requirements Report* are reported on an annual basis, we randomly assigned a quarter when eligibility for promotion and promotion completions will be considered.

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8 We used "before treatment" attempted suicide rates reported in Gibbons et al. (2007, Table 5). Veterans in this study were observed for an average of 297 days prior to treatment. We assumed that the suicide attempt rate represents an annual probability; this is likely to be a conservative estimate, given that the mean observation period was slightly less than one year.

9 Zivin et al. (2007) found 90.6 suicides per 100,000 person-years among depressed veterans, compared with 68.2 suicides per 100,000 person-years among veterans with co-morbid PTSD and depression. The ratio of these two figures, which we used to deflate our age-specific suicide attempt rates for PTSD, is 0.75.

Costs.

Treatment Costs. The cost of psychotherapy, visits with primary care physicians, and visits with psychiatrists come from TRICARE and Medicare reimbursement rates.[10] Because TRICARE reimbursement rates reported by DoD are state-specific, we took a weighted average, using counts of the number of deployed troops from each state (DoD, 2007). TRICARE reimbursement rates were assigned to active duty personnel, and Medicare reimbursement rates were assigned to those who have left DoD.

Drug costs for DoD personnel come from the Department of Defense Pharmacoeconomic Center (2004), and drug costs for non–active duty or discharged servicemembers come from the 2007 *Red Book* (Fleming, 2006) and Dobscha et al. (2007). Drug costs vary substantially depending on where an individual seeks treatment. According to the 2007 *Red Book* (Fleming, 2006), the price of a 30- to 40-milligram dose of fluoxetine is approximately $5.34 in the civilian health care sector; this compares with a price of $0.05 for a 40-milligram dose faced by DoD and the VA (Dobscha, Winterbottom, and Snodgrass, 2007; DoD Pharmacoeconomic Center, 2004). While we assumed that all active duty personnel get care through DoD, discharged veterans can seek care either through the VA health care system or through private health insurance plans provided by an employer, a spouse's employer, or an alternative source. In our baseline projections, we assumed that 35 percent of discharged veterans seek mental health care through the VA; this assumption is based on a Veterans Health Administration briefing stating that 35 percent of OEF/OIF veterans have accessed the VA health system (Veterans Health Administration, 2007). In our upper-bound cost scenario, we assumed that all discharged veterans get prescriptions through the private sector; in our lower-bound scenario, we assumed that all discharged veterans get care through the VA. In all model scenarios, we assumed that everyone who receives an anti-depressant prescription gets generic Prozac (fluoxetine), one of the least expensive selective serotonin reuptake inhibitors available on the market. This assumption is conservative, because some individuals will likely receive more expensive, brand-name drugs. Table 6.B.4 shows the costs for a three-month course of treatment that we estimate for each condition and treatment combination.

Wages. Civilian wages were estimated using a regression framework that draws on data from the 2006 Current Population Survey. The regression sample is limited to veterans who are currently working and who report positive earnings. For individuals with a mental health condition, predicted wages were reduced using rates reported by Savoca and Rosenheck (2000). Specifically, wages were reduced by 15.75 percent for individuals with PTSD and by 45.23 percent for individuals with major depression or co-morbid PTSD and major depression. Savoca and Rosenheck (2000) analyze the

[10] TRICARE reimbursement rates were found at TRICARE, "Allowable Charges," Web page, no date. Medicare reimbursement rates were found at Department of Health and Human Services, Centers for Medicare and Medicaid Services, "Physician Fee Schedule Search," Web page, no date.

Table 6.B.4
Treatment Cost Estimates Used in Model

Condition(s)	DoD	Civilian, Baseline	Civilian, Lower-Bound	Civilian, Upper-Bound
Evidence-Based Treatment				
PTSD	$1,374.48	$1,658.34	$1,334.70	$1,810.80
Major depression	$585.56	$1,099.16	$568.75	$1,349.03
Co-morbid PTSD/ major depression	$1,392.73	$2,989.13	$1,352.95	$3,759.90
Usual Care				
PTSD	$298.19	$444.93	$289.58	$518.11
Major depression	$239.57	$294.09	$232.38	$323.16
Co-morbid PTSD/ major depression	$298.19	$444.93	$289.58	$518.11

NOTE: The civilian baseline estimate assumes that 35 percent of discharged personnel get care through the VA; the lower-bound estimate assumes that all discharged personnel get care through the VA; and the upper-bound assumes that no discharged personnel get care through the VA.

relationship between wages and a mental health condition in a population of Vietnam veterans; however, for major depression, Savoca and Rosenheck's wage effect is high relative to similar studies of the civilian population. For example, Ettner, Frank, and Kessler (1997) find that employed men with a mental health condition have wage rates that are 9 to 20 percent lower than their counterparts without a mental health condition. Because Savoca and Rosenheck's major depression figure may be high, we reduced the wage penalty for major depression in our lower-bound cost estimate. Instead of a 45-percent wage reduction, our lower-bound estimate assumes a 15.75-percent wage reduction—this is equivalent to the wage reduction for PTSD and is approximately the midpoint of the wage reduction found in Ettner, Frank, and Kessler (1997).

Wages for active duty personnel were calculated by adding an individual's basic pay, housing allowance, and subsistence allowance as reported by the Office of the Secretary of Defense.[11] Because housing allowance varies depending on whether the individual has dependents, we took a weighted average, assuming that half of all returning servicemembers have dependents.[12] DoD basic pay is almost completely determined by rank and years of service. As a result, a mental health condition will not influence DoD salaries through a direct reduction in wage. However, given the civilian literature summarized in Part III/Chapter Five finding a strong association between a mental health

[11] DoD, "Military Pay and Benefits" Web page (DoD, 2008b).

[12] This is consistent with Hoge, Auchterlonie, and Milliken (2006), who report that approximately 50 percent of returning servicemembers are married.

condition and reduced wages (Ettner, Frank, and Kessler, 1997; Savoca and Rosenheck, 2000), higher missed days at work (Druss, Rosenheck, and Sledge, 2000; Kessler, Borges, and Walters, 1999), and poorer work performance (Wang et al., 2004; LeBlanc et al., 2007), we thought it was likely that a mental health condition would indirectly reduce DoD salaries through a decreased likelihood of promotion. Because we had no data that would enable us to quantify this effect, our baseline scenario assumes that productivity within DoD is reduced by half of the civilian productivity-reduction factor found in Savoca and Rosenheck (2000). Thus, for a servicemember with PTSD, DoD wages were reduced by a factor of 7.88 percent; for a servicemember with major depression or co-morbid PTSD and major depression, DoD wages were reduced by a factor of 22.62 percent. In our low-cost scenario, we assumed that a mental health condition has no effect on wages within DoD.

Suicide Costs. Health care costs attributable to suicide are based on Corso et al. (2007), who report medical costs associated with suicide attempts and completions by age and gender. We assumed that medical costs associated with suicide are equivalent for those in DoD and those in the civilian sector. We assessed the cost of lives lost to suicide using published estimates of the value of a statistical life. Viscusi and Aldy (2003) review this literature and find that estimates of the value of a statistical life based on wage-risk trade-offs have ranged from $4 million to $9 million. In an analysis of the costs of TBI, Wallsten and Kosec (2005) use the midpoint of this range ($6.5 million), but inflate it to represent 2005 dollars using the CPI. We used the same approach, but we further inflated this value to represent 2007 dollars, leading to a final estimate of $7,523,602.

Predicted Costs, Ten Model Runs. Table 6.B.5 shows the predicted costs generated in ten alternate model runs using the baseline assumptions. The first row of the table (Alternate 1) shows the model results that we report in the main text of this chapter (we report results from this scenario in the main text only because this was the first run that we generated). A key result stemming from this analysis is that the predicted number of suicides varies from run to run and that the volatility in suicides can have a large influence on costs. When we accounted for suicide mortality, total two-year costs for a cohort of 50,000 E-5s range from $147.3 million to $204.7 million, a difference of 39.0 percent. In contrast, when we exclude costs related to suicide mortality, our cost estimates range from $111.0 million to $121.9 million, a difference of 9.8 percent. As a result of the increased volatility stemming from suicide, we report model results with and without suicide mortality costs throughout this chapter.

Table 6.B.6 reports means and standard deviations of cost estimates in the high, low, and baseline scenarios for E-5s, averaged across ten model runs. When calculating totals and average costs per case, we used the status quo assumptions—30 percent get treatment and 30 percent of treatment is evidence-based. These estimates are used to derive Figures 6.4 and 6.5 in the main text. The findings in Table 6.B.6 show that, even when averaging over a relatively small number of model runs, the model estimates are

Table 6.B.5
Ten Alternate Model Runs Using Baseline Parameter Assumptions and Status Quo Treatment Assumptions, Cohort of 50,000 E-5s

Run	Total Costs, Without Suicide Mortality	Total Costs, with Suicide Mortality	Number of Suicides	Savings from Evidence-Based Treatment, Not Including Suicide Mortality	Savings from Evidence-Based Treatment, Including Suicide Mortality
Alternate 1	$119,829,381	$204,691,652	11	$1,378,881	$86,241,152
Alternate 2	$120,302,270	$183,180,920	8	$1,441,220	$7,406,270
Alternate 3	$114,214,326	$185,743,140	10	–$2,311,974	$69,216,840
Alternate 4	$111,785,505	$147,268,571	4	–$4,864,545	–$56,480
Alternate 5	$113,985,461	$150,395,996	5	–$5,249,990	$15,988,046
Alternate 6	$116,318,535	$157,390,425	6	$2,722,335	–$2,315,775
Alternate 7	$121,951,614	$158,831,390	5	$6,439,314	$29,498,690
Alternate 8	$120,699,597	$192,432,462	10	–$3,434,403	$37,705,962
Alternate 9	$111,664,698	$197,001,200	11	–$5,352,102	$36,747,050
Alternate 10	$111,021,318	$188,043,261	10	–$3,280,032	$43,724,961

NOTE: The status quo treatment assumptions are that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care. Baseline parameter assumptions are reported in Table 6.4.

Table 6.B.6
Average Status Quo Costs Found in Ten Alternate Model Runs, Cohort of 50,000 E-5s

	Baseline	Low	High
A. Includes Value of Lives Lost to Suicide			
Total costs	$176,497,901 ($20,937,686)	$49,886,346 ($5,675,280)	$217,512,552 ($16,975,703)
Per-case cost, PTSD	$10,151 ($3,359)	$8,127 ($2,597)	$11,838 ($2,422)
Per-case cost, co-morbid PTSD and major depression	$15,748 ($2,741)	$6,688 ($3,555)	$19,673 ($2,948)
Per-case cost, major depression	$22,044 ($3,934)	$11,512 ($3,809)	$27,727 ($5,879)
B. Excludes Value of Lives Lost to Suicide			
Total costs	$116,177,270 ($4,203,965)	$96,789,689 ($24,325,303)	$147,947,486 ($3,355,368)
Per-case cost, PTSD	$5,534 ($416)	$4,145 ($520)	$6,736 ($424)
Per-case cost, co-morbid PTSD and major depression	$11,486 ($416)	$4,106 ($801)	$14,606 ($388)
Per-case cost, major depression	$14,537 ($408)	$5,251 ($495)	$18,856 ($540)

NOTE: *Status quo* assumes that 30 percent of individuals with mental health conditions receive treatment and that 30 percent of individuals receiving treatment get evidence-based care. Baseline, high-cost, and low-cost parameter assumptions are reported in Table 6.4.

very stable when we exclude the cost of lives lost to suicide. In the baseline scenario, the coefficient of variation (i.e., the standard deviation divided by the mean) is 0.036, indicating that the variation in model outcomes is small relative to the estimated mean. However, the coefficient of variation in the baseline scenario is 0.119 when we include the value of lives lost to suicide. These findings further emphasize the fact that, while suicide mortality is a large and important component of costs, figures that incorporate mortality costs associated with suicide are uncertain.

References

Andrews, B., C. R. Brewin, R. Philpott, L. Stewart. Delayed-onset posttraumatic stress disorder: A systematic review of the evidence. *American Journal of Psychiatry*, Vol. 164, No. 9, 2007, pp. 1319–1326.

Angst, J. "The course of major depression, atypical bipolar disorder, and bipolar disorder," in H. Hippius et al., ed., *New Results in Depression Research.* Berlin/Heidelberg: Springer-Verlag, 1986, pp. 26–35.

Bilmes, L. *Soldiers Returning from Iraq and Afghanistan: The Long-Term Costs of Providing Veterans Medical Care and Disability Benefits.* Cambridge, Mass.: Harvard University John F. Kennedy School of Government, 2007.

Bilmes, L. and J. Stiglitz. *The Economic Costs of the Iraq War: An Appraisal Three Years After the Beginning of the Conflict.* Cambridge, Mass.: National Bureau of Economic Research, 2006.

Boake, C., S. R. McCauley, C. Pedroza, H. S. Levin, S. A. Brown, and S. I. Brundage. Lost productive work time after mild to moderate traumatic brain injury with and without hospitalization. *Neurosurgery,* Vol. 56, No. 5, 2005, pp. 994–1003.

Brooks, C. A., B. Gabella, R. Hoffman, D. Sosin, and G. Whiteneck. Traumatic brain injury: Designing and implementing a population-based follow-up system. *Archives of Physical Medicine and Rehabilitation,* Vol. 78, No. 8, Suppl. 4, 1997, pp. S26–S30.

Brooks, D. N. The head-injured family. *Journal of Clinical and Experimental Neuropsychology,* Vol. 13, 1991, pp. 155–188.

Buntin, M. B., G. M. Carter, O. Hayden, C. Hoverman, S. M. Paddock, and B. O. Wynn. *Inpatient Rehabilitation Facility Care Use Before and After Implementation of the IRF Prospective Payment System*. Santa Monica, Calif.: RAND Corporation, TR-257-CMS, 2006. As of March 2, 2008: http://www.rand.org/pubs/technical_reports/TR257/

Calhoun, P. S., and J. C. Beckham. Caregiver burden and psychological distress in partners of veterans with chronic posttraumatic stress disorder. *Journal of Traumatic Stress*, Vol. 15, No. 3, 2002, pp. 205–212.

Casacalenda, N., J. C. Perry, and K. Looper. Remission in major depressive disorder; a comparison of pharmacotherapy, pschotherapy and control conditions. *American Journal of Psychiatry,* Vol. 159, No. 8, 2002.

Casbon, T. S., J. J. Curtin, A. R. Lang, and C. J. Patrick. Deleterious effects of alcohol intoxication: Diminished cognitive control and its behavioral consequences. *Journal of Abnormal Psychology,* Vol. 112, No. 3, 2003, pp. 476–487.

Christensen, E., J. McMahon, E. S. Schaefer, T. Jaditz, and D. Harris. *Final Report for the Veterans' Disability Benefits Commission: Compensation, Survey Results, and Selected Topics*. Washington, D.C.: The CNA Corporation, 2007.

Congressional Budget Office. *Educational Attainment and Compensation of Enlisted Personnel*. Washington, D.C., February 2004. As of March 2, 2008: http://www.cbo.gov/ftpdoc.cfm?index=5108&type=0&sequence=1

Corso, P. S., J. A. Mercy, T. R. Simon, E. A. Finkelstein, and T. R. Miller. Medical costs and productivity losses due to interpersonal and self-directed violence in the United States. *American Journal of Preventive Medicine,* Vol. 32, No. 6, 2007, pp. 474–482.

De Maat, S., J. Dekker, R. Schoevers, and F. De Jonghe. Relative efficacy of psychotherapy and pharmacotherapy in the treatment of depression: A meta-analysis. *Psychotherapy Research*, Vol. 16, No. 5, pp. 566–578.

Defense Manpower Data Center. *Tabulations of Responses from the 1999 Survey of Active Duty Personnel: Volume 2*. Washington, D.C., DMDC Report No. 2000-007, September 2000. As of March 2, 2008:
http://www.dmdc.osd.mil/surveys/act_tab/pdfs/2000-007.pdf

Dekel, R., and Z. Solomon. Marital relations among former prisoners of war: Contribution of posttraumatic stress disorder, aggression, and sexual satisfaction. *Journal of Family Psychology*, Vol. 20, No. 4, 2006, pp. 709–712.

Department of Defense. "Pay and Allowances," Web page, no date-a. As of March 2, 2008:
http://www.defenselink.mil/militarypay/pay/index.html

——— "Reserve Drill Pay," Web page, no date-b. As of March 2, 2008:
http://www.defenselink.mil/militarypay/pay/bp/02_reservedrill.html

———. "U.S. Troops Deployed: Operation Enduring Freedom and Operation Iraqi Freedom, Primarily Iraq and Afghanistan," January 31, 2007. As of March 2, 2008:
http://majorityleader.house.gov/docUploads/DeployedJan312007.pdf

———. "Military Casualty Information," Web page, 2008a. As of March 2, 2008:
http://siadapp.dmdc.osd.mil/personnel/CASUALTY/castop.htm

———. "Military Pay and Benefits," Web page, January 24, 2008b. As of March 2, 2008:
http://www.defenselink.mil/militarypay/

Department of Defense, Office of the Under Secretary of Defense for Personnel and Readiness. *Population Representation in the Military Services, 2005*, 2005. As of March 2, 2008:
http://www.defenselink.mil/prhome/poprep2005

———. *Defense Manpower Requirements Report (DMRR): Fiscal Year 2007*, Washington, D.C., 2006.

Department of Defense Pharmacoeconomic Center. Selective Serotonin reuptake inhibitors. *PEC Update*, Vol. 4, No. 2, 2004. As of March 2, 2008:
http://www.pec.ha.osd.mil/Updates/0402web/Mar_04_Update_Page_7.htm

Department of Health and Human Services, Centers for Medicare and Medicaid Services. "Physician Fee Schedule Search." Web page, no date. As of March 2, 2008:
http://www.cms.hhs.gov/pfslookup/02_PFSsearch.asp

Department of Labor. National Compensation Survey: Occupational Wages in the United States, Supplementary Tables, July 2006.

Dimidjian, S., S. D. Hollon, K. Dobson, K. B. Schmaling, R. J. Kohlenberg, M. E. Addis, R. Gallop, J. B. McGlinchey, D. K. Markley, J. K. Gollan, D. C. Atkins, D. L. Dunner, and N. S. Jacobson. Randomized trial of behavioral activation, cognitive therapy, and antidepressant medication in the acute treatment of adults with major depression. *Journal of Consulting and Clinical Psychology,* Vol. 74, No. 4, 2006, pp. 658–670.

Dobscha, S. K., L. M. Winterbottom, and L. S. Snodgrass. Reducing drug costs at a veterans affairs hospital by increasing market-share of generic fluoxetine. *Community Mental Health Journal,* Vol. 43, No. 1, 2007.

Dohrenwend, B. P., J. B. Turner, N. A. Turse, et al. The psychological risks of Vietnam for U.S. veterans: A revisit with new data and methods. *Science*, Vol. 313, No. 5789, 2006, pp. 979–982.

Druss, B. G., R. Rosenheck, and W. H. Sledge. Health and disability costs of depressive illness in a major US corporation. *American Journal of Psychiatry,* Vol. 157, No. 8, 2000, pp. 1274–1278.

Du Rocher Schudlich, T. D., L. M. Papp, and E. M. Cummings. Relations of husbands and wives' dysphoria to marital conflict resolution strategies. *Journal of Family Psychology,* Vol. 18, No. 1, 2004, pp. 171–183.

Ettner, S. L., R. G. Frank, and R. C. Kessler. The impact of psychiatric disorders on labor market outcomes. *Industrial and Labor Relations Review,* Vol. 51, No. 1, 1997, pp. 64–81.

Finkelstein, E. A., P. S. Corso, and T. R. Miller. *The Incidence and Economic Burden of Injuries in the United States*. Cambridge, UK: Oxford University Press, 2006.

Fleming, T. *Redbook: Pharmacy's Fundamental Reference*. Montvale, N.J.: Thompson Healthcare, 2006.

Foa, E. B., J. R. T. Davidson, and A. Frances. Treatment of posttraumatic stress disorder. *Journal of Clinical Psychiatry,* Vol. 60, 1999.

Friedman, M. A., and J. B. Detweiler-Bedell. Combined psychotherapy and pharmacotherapy for the treatment of major depressive disorder. *Clinical Psychology: Science and Practice*, Vol. 11, 2004, pp. 47–68.

Gibbons, R. D., C. H. Brown, K. Hur, S. M. Marcus, et al. Relationship between antidepressants and suicide attempts: An analysis of the Veterans Health Administration data sets. *American Journal of Psychiatry,* Vol. 164, No. 7, 2007.

Gold, M. R., J. E. Siegel, L. B. Russell, and M. C. Weinstein. Cost-effectiveness in health and medicine. *Oxford University Press*, New York, NY, 1996.

Goldberg, M.S. *Projecting the Costs to Care for Veterans of U.S. Military Operations in Iraq and Afghanistan*. Testimony before the Committee on Veterans' Affairs, U.S. House of Representatives, Washington, D.C.: Congressional Budget Office, October 17, 2007.

Goldsmith, S., T. C. Pellmar, A. M. Kleinman, W. E. Bunney, eds. *Reducing Suicide: A National Imperative*. Washington, D.C.: National Academies Press, 2002.

Government Accountability Office. *Comprehensive Outpatient Rehabilitation Facilities: High Medicare Payments in Florida Raise Program Integrity Concerns*. Washington, D.C., GAO-04-709, 2004.

———. *Military Personnel: DoD Needs to Improve the Transparency and Reassess the Reasonableness, Appropriateness, Affordability, and Sustainability of Its Military Compensation System*. Washington, D.C., GAO-05-798, 2005.

Grieger, T. A., S. J. Cozza, R. J. Ursano, C. Hoge, P. E. Martinez, C. C. Engel, and H. J. Wain. Posttraumatic stress disorder and depression in battle-injured soldiers. *American Journal of Psychiatry,* Vol. 163, No. 10, 2006.

Harwood, H. J., D. Fountain, and G. Fountain. *The Economic Cost of Alcohol and Drug Abuse in the United States, 1992*. Bethesda, Md.: National Institute on Drug Abuse, 1998.

HCUPnet. Web site, no date. As of March 2, 2008:
http://hcupnet.ahrq.gov/

Hibbard, M. R., S. Uysal, K. Kepler, J. Bogdany, and J. Silver. Axis I psychopathology in individuals with traumatic brain injury. *Journal of Head Trauma Rehabilitation,* Vol. 13, No. 4, 1998, pp. 24–39.

Hirsch, B. T., and S. L. Mehay. Evaluating the labor market performance of veterans using a matched comparison group design. *Journal of Human Resources,* Vol. 38, No. 3, 2003, pp. 673–700.

Hodgson, T. Z., and Meiners, M. R. *Guidelines for Cost of Illness Studies in the Public Health Service: Task Force on Cost of Illness Studies*. Washington, D.C.: U.S. Public Health Services, 1979.

———. Cost-of-illness methodology: A guide to current practices and procedures. *Milbank Memorial Fund Quarterly,* Vol. 60, 1982, pp. 429–462.

Hoge, C. W., J. L. Auchterlonie, and C. S. Milliken. Mental health problems, use of mental health services, and attrition from military service after returning from deployment to Iraq or Afghanistan. *Journal of the American Medical Association,* Vol. 295, No. 9, 2006.

Hoge, C. W., C. A. Castro, S. C. Messer, D. McGurk, D. I. Cotting, and R. L. Koffman. Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *New England Journal of Medicine*, Vol. 351, No. 1, 2004, pp. 13–22.

Hoge, C. W., S. E. Lesikar, R. Guevara, J. Lange, J. F. Brundage, C. C. Engel, S. C. Messer, and D. T. Orman. Mental disorders among U.S. military personnel in the 1990s: Association with high levels of health care utilization and early military attrition. *American Journal of Psychiatry,* Vol. 159, No. 9, 2002, pp. 1576–1583.

Hoge, C. W., A. Terhakopian, C. A. Castro, S. C. Messer, and C. C. Engel. Association of posttraumatic stress disorder with somatic symptoms, health care visits, and absenteeism among Iraq war veterans. *American Journal of Psychiatry*, Vol. 164, No. 1, 2007, pp. 150–153.

Horvitz-Lennon, M., S. T. Normand, R. G. Frank, and H. H. Goldman. "Usual Care" for major depression in the 1990s: Characteristics and expert-estimated outcomes. *American Journal of Psychiatry,* Vol. 160, No. 4, 2003.

Hosek, J., and M. Mattock. *Learning About Quality: How the Quality of Military Personnel Is Revealed over Time,* Santa Monica, Calif.: RAND Corporation, MR-1593-OSD, 2003. As of March 2, 2008: http://www.rand.org/pubs/monograph_reports/MR1593/

House of Representatives. *Estimated Cost of U.S. Operations in Iraq and Afghanistan and of Other Activities Related to the War on Terrorism*. Hearing before the Committee on the Budget, October 24, 2007.

Institute of Medicine. *Treatment of PTSD: An Assessment of the Evidence*. Washington, D.C.: National Academies Press, 2007.

Ivins, B. J., K. A. Schwab, G. Baker, and D. L. Warden. Hospital admissions associated with traumatic brain injury in the US Army during peacetime: 1990s trends. *Neuroepidemiology,* Vol. 27, No. 3, 2006, pp. 154–163.

Johnstone, B., D. Mount, and L. H. Schopp. Financial and vocational outcomes 1 year after traumatic brain injury. *Archives of Phyical Medicine and Rehabilitation,* Vol. 84, No. 2, 2003, pp. 238–241.

Judd, L. L., H. S. Akiskal, J. D. Maser, P. J. Zeller, J. Endicott, W. Coryell, M. Paulus, J. L. Kunovac, A. C. Leon, C. W. Mueller, J. A. Rice, and M. B. Keller. Telephone psychotherapy and telephone care management for primary care patients starting antidepressant treatment: A randomized controlled trial. *Archives of General Psychiatry,* Vol. 55, 1998, pp. 694–700.

Judd, L. L., M. J. Paulus, P. J. Schettler, H. S. Akiskal, J. Endicott, A. C. Leon, J. D. Maser, T. Mueller, D. A. Solomon, and M. B. Keller. Does incomplete recovery from first lifetime major depressive episode herald a chronic course of illness? *American Journal of Psychiatry,* Vol. 157, No. 9, 2000, pp. 1501–1504.

Keller, M. B., J. P. McCullough, D. N. Klein, and B. Arnow. A comparison of Nefazodone, the cognitive behavioral-analysis system of psychotherapy, and their combination for the treatment of chronic depression. *New England Journal of Medicine*, Vol. 342, No. 20, 2000, pp. 1462–1471.

Kennedy, N., R. Abbott, and E. S. Paykel. Longitudinal syndromal and sub-syndromal symptoms after severe depression: 10-year follow-up story. *British Journal of Psychiatry,* Vol. 184, 2004, pp. 330–336.

Kessler, R. C., G. Borges, and E. E. Walters. Prevalence of and risk factors for lifetime suicide attempts in the National Comorbidity Survey. *Archives of General Psychiatry,* Vol. 56, 1999, pp. 617–626.

Kessler, R. C., A. Sonnega, E. Bromet, M. Huges, and C. Nelson. Posttraumatic stress disorder in the National Comorbidity Survey. *Archives of General Psychiatry*, Vol. 52, 1995, pp. 1048–1060.

Kilburn, M. R., R. Louie, and D. Goldman. *Patterns of Enlisted Compensation,* Santa Monica, Calif.: RAND Corporation, MR-807-OSD, 2001. As of March 2, 2008: http://www.rand.org/pubs/monograph_reports/MR807/

Kocsis, J. H., A. J. Frances, C. Voss, J. J. Mann, B. J. Mason, and J. Sweeney. Imipramine treatment for chronic depression. *Archives of General Psychiatry*, Vol. 45, 1988, pp. 253–257.

Kozloff, R. Networks of social support and the outcome for severe head injury. *Journal of Head Trauma Rehabilitation,* Vol. 2, 1987, pp. 14–23.

Kulka, R. A., W. E. Schlenger, J. A. Fairbank, R. L. Hough, B. K. Jordan, C. R. Marmar, et al. *Trauma and the Vietnam War Generation: Report of Findings from the National Vietnam Veterans Readjustment Study*. Philadelphia, Penn.: Brunner/Mazel, 1990.

LeBlanc V. R., C. Regehr, R. B. Jelley, and I. Barath. Does posttraumatic stress disorder affect performance? *Journal of Nervous and Mental Disease*, Vol. 195, No. 8, 2007, pp. 701–704.

Lewin-ICF. *The Cost of Disorders of the Brain.* Washington, D.C.: The National Foundation for Brain Research, 1992.

Liss, M., and B. Willer. Traumatic brain injury and marital relationships: A literature review. *International Journal of Rehabilitation Research,* Vol. 13, No. 4, 1990, pp. 309–320.

Ludman, E. J., G. E. Simon, S. Tutty, and M. Von Korff. A randomized trial of telephone psychotherapy and pharmacotherapy for depression: Continuation and durability of effects. *Journal of Consulting and Clinical Psychology,* Vol. 75, No. 2, 2007, pp. 257–266.

Max, W., E. J. MacKenzie, and D. P. Rice. Head injuries: Costs and consequences. *Journal of Head Trauma Rehabilitation,* Vol. 6, 1991, pp. 76–91.

Medical Surveillance Monthly Report (MSMR): A Publication of the Armed Forces Health Surveillance Center, Vol. 14, No. 6, September–October, 2007.

Melfi, C. A., A. J. Chawla, T. W. Croghan, M. P. Hanna, S. Kennedy, and K. Sredl. Reducing relapse and recurrence in unipolar depression: A comparative meta-analysis of cognitive-behavioral therapy's effects. *Archives of General Psychiatry,* Vol. 55, 1998, pp. 1128–1132.

Miller, T. R., J. B. Douglass, M. S. Galbraith, D. C. Lestina, and N. M. Pindus. "Costs of head and neck injury and a benefit-cost analysis of bicycle helmets," in *Head and Neck Injury.* Warrendale, Penn.: Society of Automotive Engineers, Inc., 1994, pp. 211–240.

Milliken, C. S., J. L. Auchterlonie, and C. W. Hoge. Longitudinal assessment of mental health problems among Active and Reserve Component soldiers returning from the Iraq war. *Journal of the American Medical Association*, Vol. 298, No.18, 2007, pp. 2141–2148.

Ommaya, A. K., A. M. Salazar, A. L. Dannenberg, A. K. Ommaya, A. B. Chervinsky, and K. Schwab. Outcome after traumatic brain injury in the U.S. military medical system. *Journal of Trauma,* Vol. 41, No. 6, 1996, pp. 972–975.

Pampallona, S., and P. Bollini. Combined pharmacotherapy and psychological treatment for depression. *Archives of General Psychiatry*, Vol. 61, 2004, pp. 714–719.

Perconte, S. T., M. L. Griger, and G. Bellucci. Relapse and rehospitalization of veterans two years after treatment for PTSD. *Hospital and Community Psychiatry,* Vol. 40, No. 10, 1989.

President's Commission on Care for America's Returning Wounded Warriors. *Serve, Support, Simplify: Report of the President's Commission on Care for America's Returning Wounded Warriros*. July 2007.

Rice, D. P., S. Kelman, and L. S. Miller. Estimates of economic costs of alcohol and drug abuse and mental illness, 1985 and 1988. *Public Health Reports,* Vol. 106, No. 3, 1991, pp. 281–292.

Rosenheck, R., and A. Fontana. A model of homelessness among male veterans of the Vietnam War generation. *American Journal of Psychiatry,* Vol. 151, No. 3, 1994, pp. 421–427.

———. Recent trends in VA treatment of post-traumatic stress disorder and other mental disorders. *Health Affairs,* Vol. 26, No. 6, 2007.

Salazar, A. M., D. L. Warden, K. Schwab, J. Spector, S. Braverman, J. Walter, R. Cole, M. M. Rosner, E. M. Martin, J. Ecklund, and R. G. Ellenbogen. Cognitive rehabilitation for traumatic brain injury: A randomized trial. Defense and Veterans Head Injury Program (DVHIP) Study Group. *Journal of the American Medical Association,* Vol. 283, No. 23, 2000, pp. 3075–3081.

Savoca, E., and R. Rosenheck. The civilian labor market experiences of Vietnam-era veterans: The influence of psychiatric disorders. *Journal of Mental Health Policy and Economics,* Vol. 3, 2000, pp. 199–207.

Schnurr, P. P., M. J. Friedman, C. C. Engel, E. B. Foa, M. T. Shea, B. K. Chow, P. A. Resick, V. Thurston, S. M. Orsillo, R. Haug, C. Turner, and N. Bernardy. Cognitive behavioral therapy for posttraumatic stress disorder in women: A randomized controlled trial. *Journal of the American Medical Association*, Vol. 297, No. 8, 2007, pp. 820–830.

Schoenbaum, M., J. Unutzer, C. D. Sherbourne, N. Duan, L. V. Rubenstein, J. Miranda, L. S. Meredith, M. F. Carney, and K. Wells. Cost-effectiveness of practiced-initiated quality improvement for depression: Results of a randomized controlled trial. *Journal of the American Medical Association,* Vol. 286, No. 11, 2001, pp. 1325–1330.

Simon, G. E., E. J. Ludman, S. Tutty, B. Operskalski, and M. Von Korff. Telephone psychotherapy and telephone care management for primary care patients starting antidepressant treatment: A randomized controlled trial. *Journal of the American Medical Association*, Vol. 292, No. 8, 2004, pp. 935–942.

Simpson, G., and R. Tate. Suicidality after traumatic brain injury: Demographic, injury and clinical correlates. *Psychological Medicine,* Vol. 32, No. 4, 2002, pp. 687–697.

———. Clinical features of suicide attempts after traumatic brain injury. *Journal of Nervous and Mental Disease,* Vol. 193, No. 10, 2005, pp. 680–685.

Smith, M. W., P. P. Schnurr, and R. A. Rosenheck. "Employment outcomes and PTSD symptom severity. *Mental Health Services Research,* Vol. 7, No. 2, 2005, pp. 89–101.

Solomon, Z., M. Waysman, G. Levy, B. Fried, M. Mikulincer, R. Benbenishty, V. Florian, and A. Bleich. From front line to home front: A study of secondary traumatization. *Family Process Journal,* Vol. 31, No. 3, 1992, pp. 289–302.

Stewart, W. F., J. A. Ricci, E. Chee, S. R. Hahn, and D. Morganstein. Cost of lost productive work time among US workers with depression. *Journal of the American Medical Association,* Vol. 289, No. 23, 2003.

Teasdale, T. W., and A. W. Engberg. Suicide after traumatic brain injury: A population study. *Journal of Neurology, Neurosurgery, and Psychiatry,* Vol. 71, No. 4, 2001, pp. 436–440.

Thurman, D. J., "The epidemiology and economics of head trauma," in L. P. Miller and R. L. Hayes, eds., *Head Trauma: Basic, Preclinical, and Clinical Directions,* New York: John Wiley and Sons, Inc., 2001.

TRICARE. "Allowable Charges." Web page, undated. As of March 2, 2008:
http://www.tricare.mil/allowablecharges/default.aspx

U.S. Army, Suicide Risk Management and Surveillance Office, Army Behavioral Health Technology Office. *2006 Army Suicide Event Report*. Tacoma, Wa.: Madigan Army Medical Center, August 2007.

Veterans Health Administration, Office of Public Health and Environmental Hazards. "Analysis of VHA Healthcare Utilization Among US Global War on Terrorism Veterans: Operation Iraqi Freedom and Operation Enduring Freedom." Power Point Presentation, October 2007.

Viscusi, W. K., and J. E. Aldy. The value of a statistical life: A critical review of market estimates throughout the world. *Journal of Risk and Uncertainty,* Vol. 27, No. 1, 2003, pp. 5–76.

Vittengl, J. R., L. A. Clark, T. W. Dunn, and R. B. Jarrett. Reducing relapse and recurrence in unipolar depression: A comparative meta-analysis of cognitive-behavioral therapy's effects. *Journal of Consulting and Clinical Psychology,* Vol. 75, No. 3, 2007, pp. 475–488.

Wells, K. B., M. A. Burnam, W. Rodgers, R. Hays, and P. Camp. The course of depression in adult outpatients: Results from the Medical Outcomes Study. *Archives of General Psychiatry*, Vol. 49, 1992, pp. 788–794.

Wallsten, S., and K. Kosec. *The Economic Costs of the War in Iraq*. AEI-Brookings Joint Center for Regulatory Studies Working Paper 05-19, 2005.

Wang, J. L. A longitudinal population-based study of treated and untreated major depression. *Medical Care*, Vol. 42, No. 6, 2004, pp. 543–550.

Wang, P. S., A. L. Beck, P. Berglund, D. K. McKenas, N. P. Pronk, G. E. Simon, and R. C. Kessler. Effects of major depression on moment-in-time work performance. *American Journal of Psychiatry*, Vol. 161, No. 10, 2004, pp. 1885–1891.

Wang, P. S., G. E. Simon, J. Avorn, F. Azocar, E. J. Ludman, J. McCulloch, M. Z. Petukhova, and R. C. Kessler. Telephone screening, outreach, and care management for depressed workers and impact on clinical and work productivity outcomes. *Journal of the American Medical Association,* Vol. 298, No. 12, 2007, pp. 1401–1411.

Wang, P., M. L. Olfson, H. A. Pincus, K. B. Wells, and R. C. Kessler. Twelve-month use of mental health services in the United States: Results from the National Comorbidity Survey Replication. *Archives of General Psychiatry*, Vol. 62, 2005 pp. 629–640.

Whooley, M. A., and G. Simon. Managing depression in medical outpatients. *New England Journal of Medicine*, Vol. 343, No. 26, 2000, pp. 1942–1950.

Wolfe, J. W., D. J. Erickson, E. J. Sharkansky, D. W. King, and L. A. King. Course and predictors of posttraumatic stress disorder among Gulf War veterans: A prospective analysis. *Journal of Consulting and Clinical Psychology,* Vol. 67, No. 4, 1999, pp. 520–528.

Young, A. S., K. Kapur, and D. Murata. The time course of treatment costs among patients with severe mental illness. *Psychiatric Services*, Vol. 52, No. 1, 2001.

Young, A. S., R. Klap, C. D. Sherbourne, and K. Wells. The quality of care for depressive and anxiety disorders in the United States. *Archives of General Psychiatry,* Vol. 58, 2001.

Zatzick, D. F., C. R. Marmar, D. S. Weiss, W. S. Browner, T. J. Metzler, J. M. Golding, A. Stewart, W. E. Schlenger, and K. B. Wells. Posttraumatic stress disorder and functioning and quality of life outcomes in a nationally representative sample of male Vietnam veterans. *American Journal of Psychiatry,* Vol. 154, No. 12, 1997, pp. 1690–1695.

Zivin, K., H. M. Kim, J. F. McCarthy, K. L. Austin, K. J. Hoggatt, H. Walters, and M. Valenstein. Suicide mortality among individuals receiving treatment for depression in the Veterans Affairs Health System: Associations with patient and treatment setting characteristics. *American Journal of Public Health*, Vol. 97, No. 12, 2007, pp. 2193–2198.