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Understanding recent estimates of PTSD and TBI from Operations Iraqi Freedom and Enduring Freedom

As of late summer 2009, some 5,000 U.S. troops had died and 35,000 had been wounded in action during Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) in Afghanistan. The fraction of wounded troops who survive their injuries is higher than in previous conflicts, such as Vietnam [1–2]. Enhanced survival is a desirable outcome; however, many policy makers and commentators have expressed concerns about the ensuing healthcare needs of wounded servicemembers and veterans. In particular, much attention has recently focused on mild traumatic brain injuries (TBIs), posttraumatic stress disorder (PTSD), and other mental health conditions. Some 80 percent of TBI diagnoses stemming from OIF/OEF have been associated with closed (as opposed to penetrating) head injuries, suggesting that many more TBIs may have gone undiagnosed.* Servicemembers who survive gunshot wounds, explosions, or other kinetic events may suffer PTSD but so too may many others who do not receive physical injuries and, again, are not identified.

Although individuals who develop PTSD symptoms or sustain mild TBIs (concussions) often regain normal function without treatment, others recover only after medical intervention. To date, no definitive count is available of servicemembers and veterans who were ever deployed to the conflicts in Iraq or Afghanistan and are impaired by PTSD or TBI. Nonetheless, the specter of large numbers of servicemembers and veterans suffering—undiagnosed and requiring treatment—has been raised by a number of researchers and embraced by the popular press. For an excellent overview of scholarly publications on PTSD and TBI prevalence, see Ramchand et al. [3].

Understanding the scope of these problems helps decision makers effectively allocate scarce healthcare resources; conversely, reliance on incorrect prevalence rates can result in oversupply of medical personnel and equipment in some areas, while other medical services suffer from shortages and excessive waiting times. As recently indicated in an article by Colonel Charles Hoge (Director of the Division of Psychiatry and Neuroscience at Walter Reed Army Institute of Research) and his colleagues, the presage of large numbers of servicemembers with debilitating TBI and PTSD may fuel undesirable clinical and budgetary consequences: unproductive and time-consuming testing, inappropriate treatment and medication, and reinforcement of patients' negative perceptions [4].

There are three main problems with relying on extant studies to estimate the prevalence rates of TBI and PTSD in the full OIF/OEF population. First, the studies generally report the percentage of servicemembers who screen

*Data provided by the Department of Defense, August 2007.

positive for TBI or PTSD, not those who have been diagnosed with the condition by an appropriately trained medical provider. Second, the study samples are not representative of the entire ever-deployed military population. Third, the degree of impairment for servicemembers who have or have had TBI or PTSD is unknown.

Although studies often estimate rates of TBI and PTSD with a screening questionnaire, those tools do not replace a clinician-determined diagnosis. For one, screening tools are not comprehensive—typically they do not survey respondents regarding all the symptoms and conditions necessary for a diagnosis. Further, for conditions in which the underlying prevalence in the population is relatively low, screening tools are likely to overestimate the number of cases, particularly when the tool is designed to capture as many potential cases as possible. For example, suppose that 90 percent of people with a certain disease screen positive (sensitivity = 0.90) and 5 percent of those without the disease also screen positive (specificity = 0.95). If the true population prevalence is 10 percent and 1,000 people are screened, a total of 135 people (13.5%) would be expected to test positive: 90 percent of the 100 people (90) who have the disease and 5 percent of the 900 people (45) who do not (false positives). In this example, the rate of screening positive is 35 percent higher than the true prevalence of the disease; put differently, one-third of the positive screens are false positives. When the population prevalence is low, the specificity does not have to lie much below 1.0 to generate significant numbers of false positive readings.

Most of the published studies on TBI and PTSD examine a subsample of servicemembers who have deployed to OIF/OEF—often combat troops in the Army or Marine Corps, less frequently including support personnel (such as truck drivers or supply handlers) or personnel from the Navy or Air Force. Although these results may be important in themselves, they cannot be directly extrapolated to the entire deployed force. Other occupations and service branches are likely to see lower levels of combat and consequently, all else being equal, experience lower levels of TBI and PTSD. Even studies that purport to have surveyed the entire deployed force may not be completely representative because certain servicemembers may be more likely than others to respond to a survey. While researchers can attempt to mitigate the problem by weighting the respondents to mimic the demographic or service characteristics of the force, this tactic may not be wholly successful.

Attempts to count all servicemembers with any particular condition are not beneficial unless they are coupled with efforts to determine which of those injured require treatment. Indeed, the long-run clinical significance of an injury without impairment is unclear. Estimates of PTSD and TBI are rarely placed into this context, leading readers to believe that anyone who screens positive needs treatment.

To demonstrate these concerns, we examine the prevalence rates reported by several recent publications, the methodologies used in those studies, and some pitfalls of those methodologies.

PREVALENCE OF TBI

One of the most widely cited studies of OIF/OEF veterans' health is the RAND Corporation's book, *Invisible Wounds of War* [5]. RAND reports a "probable" TBI prevalence of 19.5 percent (95% confidence interval of 16.4%–22.7%). Applying the point-estimate prevalence rate to the population of 1.64 million troops who had served in Iraq or Afghanistan through October 2007, RAND estimates that 320,000 veterans of those conflicts sustained probable TBIs. A second article by Terrio et al. estimated a higher rate of 22.8 percent for soldiers in an Army brigade combat team returning from a 1-year deployment to Iraq [6]. Terrio et al. also examined the frequency of continued medical complaints that may be attributed to TBI, including headache, irritability, dizziness, balance problems, and memory problems, among these soldiers. The authors found that 9 percent of personnel within the brigade reported at least one ongoing symptom potentially related to TBI and 4 percent reported a minimum of two ongoing symptoms upon return.

Both sets of researchers estimated TBI prevalence based on the responses from a three-question (multipart) screening tool known as the Brief Traumatic Brain Injury Screen (BTBIS). The first question asked whether during deployment the respondent sustained any injuries due to fragment, bullet, vehicular incident, fall, blast, or other causes. The second question asked whether following such an injury the respondent was dazed, confused, or saw stars; did not remember the injury; or lost consciousness [7–8]. RAND researchers considered the test positive for probable TBI if the individual endorsed any of the injuries listed in the first question and reported any alteration of consciousness detailed in the second question. Terrio et al. used the same screening criteria but followed up with a clinical assessment.

There are several concerns with these prevalence estimates. First, as affirmed by the RAND authors, the TBI screen has never been validated against actual clinical diagnoses. The developers of the BTBIS have cross-validated their screen against two other instruments and against a brief clinical interview that was used to determine the need for additional medical evaluation and treatment [9]. Nonetheless, we do not know how much faith to place in prevalence rates estimated from the BTBIS in the absence of validation against a "gold standard" clinical diagnosis at the time of the injury. Further, it has been suggested that even a clinical diagnosis of TBI upon return from deployment may be imprecise because alteration of consciousness in combat could result from acute stress, sleep deprivation, or other war chaos [4,10].

Understanding the healthcare needs of servicemembers and veterans is complicated because most studies do not examine the impairment of individuals who experienced TBI. Even an incontrovertible diagnosis of TBI indicates only that the injury was sustained but does not reveal the persistence or intensity of symptoms at the time of the interview. Indeed, the literature indicates that the vast majority of individuals who experience a mild TBI recover from the injury [11–12]. However, accurate estimates of the number of servicemembers and veterans with continuing impairment caused by TBI have not been reported. As stated by Hoge et al., "Substantial evidence demonstrates the difficulty of attributing symptoms to mild TBI, suggesting that clinical interviews will result in erroneous conclusions" [4]. Terrio et al. recognized that symptoms ascribed to TBI by servicemembers may instead be attributable to other medical conditions. Likewise, the RAND authors acknowledged, "Most individuals who screen positive for having experienced a probable TBI are likely to have full cognitive functioning."

PREVALENCE OF PTSD

The same RAND study estimated a PTSD prevalence of 13.8 percent (95% confidence interval of 11.1%–16.5%) or that 226,000 of the veterans who served in OIF/OEF through October 2007 suffer from "probable" PTSD. A recent study by Milliken et al. examining military postdeployment health assessments estimated that 12 percent of active Army personnel and 13 percent of Army reservists screened positive for PTSD symptoms immediately upon returning from deployment [13]. Those rates rose to 17 and 25 percent of active and reserve soldiers, respectively, at the second assessment at about 6 months postdeployment.

The RAND study based its prevalence estimate on responses to a telephone administration of the PTSD Checklist (PCL). The PCL module contains 17 questions covering the three symptom clusters of PTSD: reexperiencing trauma, avoidance, and hyperarousal. Each question is scored on a 5-point scale with a maximum possible score of 85. One scoring method assesses a probable case of PTSD if the respondent endorses (with a value of at least 3 on the 5-point scale) at least one reexperiencing symptom, at least three avoidance symptoms, and at least two symptoms of hyperarousal. The RAND study asserted that the PCL scored via this method (the cluster method) has a sensitivity of 1.00 and a specificity of 0.92. However, psychometric research has shown that the sensitivity and specificity of a given instrument may vary widely depending on the population to which the instrument is applied [14]. The particular study that RAND cited as validation of the cluster method relied on a relatively small sample

(n = 65) of mothers of pediatric cancer survivors with low prevalence of PTSD [15]. Those validation statistics may not apply to the ever-deployed military population, which was subject to a different set of stresses and is 88 percent male. A recent study estimated the validity of the cluster method in a sample of male veterans and found a sensitivity of 0.72 and specificity of 0.79 [16].

Milliken et al. based their study on responses to the military's health assessments given to servicemembers immediately upon their return home and again about 6 months later [13]. The four-question Primary Care-PTSD screen (PC-PTSD) asks respondents whether they experienced certain symptoms in the past month due to a traumatic event. A positive screen was recorded if the respondent endorsed at least two of the four PTSD-related items. One validation study found that the PC-PTSD has a sensitivity of 0.91 and a specificity of 0.72, although a different study reported statistics of 0.73 and 0.88, respectively [17–18]. As in the previous example, the combination of a low population prevalence and an imperfect sensitivity may lead to overestimation of the prevalence by one-third or more.

Different researchers use alternative criteria to score both the PCL and the PC-PTSD. We have described the cluster method for the PCL, but others use a simple cutoff, such as a score of 45 or 50 relative to the maximum possible of 85. Similarly, Milliken et al. also used a 3-out-of-4 threshold for scoring the PC-PTSD. The alternative scoring criteria may lead to very different prevalence estimates. For example, Milliken et al. reported that using a threshold of 3 out of 4 rather than 2 out of 4 almost halved their estimate to 6.2 from 11.8 percent for active Army soldiers immediately postdeployment [13].

PROBLEM OF UNREPRESENTATIVE SAMPLES

Because the samples are not representative, none of the results we have cited thus far can be directly applied to the entire ever-deployed military population. The Terrio et al. and Milliken et al. articles examined soldiers in Army combat units and all deployed Army soldiers, respectively. Using data from combat troops may yield estimates too high to be applied to the entire force. Although all deployed soldiers are subject to stress, combat has long been linked to higher rates of PTSD; Vietnam veterans with high levels of exposure to war-zone stress had rates of PTSD four times higher than those of other veterans who deployed but had lower exposure [19]. On the other hand, Terrio et al.'s and Milliken et al.'s estimates may be too low to the extent that their samples excluded soldiers who were injured in theater or who left the Army before filling out a postdeployment health questionnaire as well as members of the other service branches who saw less direct combat.

To estimate the magnitude of these biases, we revisit Milliken et al.'s estimate of PTSD symptoms for Army personnel immediately postdeployment. First, any extrapolation to Navy and Air Force personnel must account for the lower exposure to combat stress among members of those branches. We roughly estimated PTSD prevalence for sailors and airmen as the midpoint between the rate for soldiers returning from deployment in Iraq and their corresponding rate just prior to deployment [20]; with this adjustment, the Department of Defense (DOD)-wide estimate of PTSD symptoms across all four service branches is 11.0 percent versus the weighted average of 12.1 percent for active and reserve Army personnel. We further consider that about 3 percent of all U.S. troops (Army or other branches) in Iraq or Afghanistan (some 55,000 through May 2009) have been medically evacuated (not all because of combat injuries) and once removed from their units may not fill out postdeployment health questionnaires [21–22]. Moreover, those who were hospitalized have been found to exhibit more symptoms of PTSD than other troops; according to Hoge et al., troops who were hospitalized are 2.46 times as likely as others to screen positive for any mental health problem (not just PTSD) [23]. Combining both effects, we revise Milliken's estimate of 12.1 percent of Army personnel with PTSD symptoms to an estimate of 11.4 percent of all OIF/OEF ever-deployed servicemembers immediately upon return from deployment.

RAND's survey was not representative of the ever-deployed military population either. Although the

authors weighted their sample to reflect demographic characteristics, they did not account for features of and events occurring during deployment. The (weighted) percentage of servicemembers who claimed to have returned from their second or higher deployment was 47 percent; population-based data from DOD indicate that through February 2008, only 36 percent of servicemembers who had deployed to either Iraq or Afghanistan did so multiple times.*

Successive deployments are associated with increased risk of PTSD; one study found that 27 percent of senior enlisted soldiers on their third or fourth deployment reported any type of mental health problem compared with 19 percent of soldiers on their second deployment and 12 percent on their first deployment [24]. In addition, some 10.7 percent of RAND's sample reported having sustained an injury for which they required hospitalization while deployed. With medical evacuations totaling 3 percent of deployed personnel, the RAND study may have oversampled hospitalized troops by as much as a factor of three. According to RAND's own estimates, individuals who were "seriously injured" are 30.5 percent more likely to screen positive for PTSD when other factors are controlled in a multivariate analysis; at the other end of the range is the relative risk of 2.46 reported by Hoge et al. [23]. Combining the effect of oversampling multiple deployments and hospitalizations and applying a range of estimates to the latter, we find that RAND's estimate of 226,000 veterans with probable PTSD through October 2007 may be too high by between 16,000 and 33,000.

PRACTICAL CONSIDERATIONS

Screening tools have two main uses: identifying individuals who might have a medical condition that warrants further evaluation and treatment and estimating population prevalence for both clinical guidance and resource allocation. Estimating prevalence from screening results is likely to be inaccurate; a full medical diagnosis by a trained provider will more precisely measure the extent of the condition. However, because researchers conducting epidemiological studies seldom have the time and other resources to conduct a full diagnostic examination on every subject, we have little choice but to rely on prevalence estimates based on screening tools administered to subsamples of a population. Still, caution is warranted when interpreting published estimates of TBI and PTSD prevalence for OIF/OEF servicemembers. Existing studies are suggestive but not definitive and likely overestimate the number of TBI and PTSD cases for the entire ever-deployed force.

Finally, it is worth noting that prevalence rates are not static. A complete profile of the course of these conditions can be obtained only through longitudinal study of OIF/OEF veterans; existing shorter-term studies are informative but must be interpreted in light of the biases examined in this editorial. The clinical usefulness of reporting injury rates without current impairment is questionable. The healthcare needs of veterans affected by mild TBI, PTSD, and other combat-related mental health conditions are clearly important, but returning troops have many other health concerns as well. Overestimates of the prevalence or cost of OIF/OEF "signature" injuries can deflect attention and resources away from other pressing needs.

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