

Model-Based Policy Analysis to Mitigate Post-Traumatic Stress Disorder

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Abstract A wide range of modeling methods have been used to inform health policies. In this chapter, we describe three models for understanding the complexities of post-traumatic stress disorder (PTSD), a major mental disorder. The models are: (1) a qualitative model describing the social and psychological complexities of PTSD treatment; (2) a system dynamics model of a population of PTSD patients in the military and the Department of Veterans Affairs (VA); and (3) a Monte Carlo simulation model of PTSD prevalence and clinical demand over time among the OEF/OIF population. These models have two characteristics in common. First, they take systems approaches. In all models, we set a large boundary and look at the whole

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system, incorporating both military personnel and veterans. Second, the models are informed by a wide range of qualitative and quantitative data. Model I is rooted in qualitative data, and models II and III are calibrated to several data sources. These models are used to analyze the effects of different policy alternatives, such as more screening, more resiliency, and better recruitment procedures, on PTSD prevalence. They also provide analysis of healthcare costs in the military and the VA for each policy. Overall, the developed models offer examples of modeling techniques that incorporate a wide range of data sources and inform policy makers in developing programs for mitigating PTSD, a major premise of policy informatics.

List of Abbreviations

DOD	Department of defense
OEF	Operation enduring freedom
OIF	Operation Iraqi freedom
PTSD	Post-traumatic stress disorder
VA	Veterans affairs

Introduction

Policy informatics refers to the use of information technologies, data analysis, computational modeling, and simulation techniques to address complex public policy problems (Johnston 2015). The goal is to utilize multiple and extensive data sources and computational methods to inform policy makers and to help improve the design and implementation of policies (Ghaffarzadegan et al. 2015; Kim et al. 2013). A broad definition of policy informatics includes data-driven system dynamics models and other mathematical models developed to study complex systems (Ghaffarzadegan et al. 2015). Example applications include studies of social welfare (Zagonel et al. 2004), environment and energy (Sterman 2014), education systems (Ghaffarzadegan et al. 2014), and healthcare systems (Fallah-Fini et al. 2014; Sabounchi et al. 2014; Teytelman and Larson 2013; Wittenborn et al. 2016). Specifically, in the domain of health care, growing attention has been paid to developing models that can capture population health and prevalence of chronic health conditions or infectious diseases and be used as platforms to test policy alternatives (Finkelstein et al. 2015; Homer and Hirsch 2006; Milstein et al. 2011).

In this chapter, we focus on the application of simulation-based models in a specific mental health policy context, the problem of post-traumatic stress disorder among military personnel and veterans. The materials in this chapter are based on the outputs of modeling different aspects of PTSD in the Post-Traumatic Stress Innovation project that was conducted at the Massachusetts Institute of Technology

from 2012 to 2015. Here, we provide brief information about PTSD and the results of the three models. The main contribution of this chapter is to provide three diverse examples of applications of policy informatics tools to study one major societal problem. The models provide examples of how modeling techniques that utilize a wide range of qualitative and quantitative data sources can help analyze a major health issue and inform policy makers. Furthermore, the chapter aims at depicting how, under the umbrella of policy informatics, different modeling techniques can provide different types of insights about a major societal problem with policy implications.

What Is PTSD?

Post-traumatic stress disorder is a mental illness that can occur after a person experiences a traumatic event, such as combat, family violence, sexual assault, a terrorist attack, or serious injury (US Department Of Veterans Affairs 2016a). Individuals suffering from PTSD continue to experience the psychological effects of trauma long after being moved from the original stressor. Symptoms include re-experiencing events, urges to avoid similar stimuli, negative cognition and mood, and increased physical arousal (Solomon et al. 2015). PTSD comorbidities include other psychological effects or mental illnesses that can occur as an effect of trauma, such as depression (Campbell et al. 2007; Ginzburg et al. 2010), substance abuse (Breslau et al. 2003; McFall et al. 1992), guilt and shame (Hendin and Haas 1991; Henning and Frueh 1997), and suicidality (Jakupcak et al. 2009).

PTSD has become a serious public health challenge. About eight million people in the United States suffer from PTSD (US Department Of Veterans Affairs 2016b). The illness is more common among military personnel and Veterans, especially those deployed to combat zones. It is estimated that 11–20% of US military personnel who served in Iraq or Afghanistan have diagnosed or undiagnosed PTSD (US Department Of Veterans Affairs 2016b).

The military PTSD burden incorporates not only the medical challenge of treatment, but also social dimensions that interact with cultural and logistical aspects of the military system. In 2007, the Department of Defense Task Force on Mental Health outlined four goals for improving mental health care, considering both medical and non-medical factors. These goals were to foster a culture of support for psychological health, a full continuum of excellent care in both peacetime and wartime, sufficient and appropriate resources allocated to prevention, early intervention, and treatment, and visible and empowered leaders at all levels to advocate, monitor, plan, coordinate and integrate prevention, early intervention, and treatment (Department of Defense Task Force on Mental Health 2007). Though this effort is an important step in normalizing care-seeking and improving access to mental health services, cultural factors such as stigma and fear of professional repercussions still prevent many individuals from seeking the care they need (Ghaffarzadegan and Larson 2015; Phelan 2005; Vogt 2011).

Moreover, the tools and techniques used for screening and diagnosis are mainly based on self-reported surveys. In order to diagnose PTSD, individuals usually answer a survey consisting of 17 questions, referred to as a post-traumatic stress checklist (Hoge et al. 2014). Each question receives a score of 1 to 5, with a possible total of 17 to 85. While there is not a precise cutoff value, generally people with numbers above 40 or 50 are considered to have PTSD symptoms and are sent for interviews and diagnosis with mental health professionals. Since this is a self-reported survey, it is not difficult to hide symptoms and manipulate responses. This adds to the uncertainties and difficulties of PTSD diagnosis.

Our Project

Mathematical models are well-known to the Department of Defense (DoD). The very birth of operations research, which relies heavily on mathematical models, was DoD-driven during World War II. Among the products of this work were efficient linear programming algorithms to improve wartime logistics; the theory of optimal search, which proved invaluable to US efforts in the North Atlantic to find and destroy enemy submarines; and optimal location theory, which proved most useful for placement of radar stations in Britain to detect incoming enemy aircraft.

However, models of human health and behavior and interventions to improve them were less well-developed at that time. The subsequent seven decades have seen a lot of good work in this area, focused less on hardware-dominated tactical operations and more on human systems. Epidemiology is now a mature field involving many different types of mathematical models of behavior-influenced disease progression and control. In the case of PTSD, mathematical modeling is a relatively new field, and there are just a handful of papers addressing the topic.

The goal of the innovation project has been to incorporate work based on both qualitative and quantitative modeling as a way to capture the potential benefits of a multidisciplinary examination of the burden of PTSD and how it might be addressed in the military health system going forward. Our mathematical modeling work takes a “system” perspective, embedding service members in the military system and then structuring various PTSD-focused models around that, with the type of structure depending on the decisions and policies to be guided and influenced by the model. From the systems point of view, we seek first to frame the problem to understand the overlapping and intertwined subsystems—formal and informal, positive and negative—that influence the treatment of PTSD. Then, from an aggregate level, we seek to project PTSD treatment workloads of the DoD and the VA over the coming years and even decades.

Mathematical models come in many varieties: deterministic or probabilistic; equation-based, or algorithm-based; simulation-based or solution-based; optimizing or descriptive; and so on. Our approach is simulation-based and descriptive in response to the complexity of PTSD. Simulations also come in a number of varieties: Monte Carlo (probabilistic) simulation, system dynamics, and even micro

rule-based such as agent-based simulations. Our work utilizes system dynamics and Monte Carlo simulations.

Simulation models have a wide variety of uses. Among others, they support “*what-if*” analysis. A simulation model of a PTSD treatment system can project the multi-year consequences of PTSD workloads and costs under a wide variety of “what-if” scenarios, ranging from those largely outside the control of the PTSD system, such as the intensity of engagements in future wars, to those under the control of the PTSD system, such as the deployment of additional resources and the use of new evidence-based treatments. This can inform projections of budgets and needs for professional manpower and facilities.

Another use is to *improve the understanding of a system*. Sometimes, a model’s primary use is problem framing, through which decision makers and other stakeholders—such as PTSD-afflicted service members and veterans, their families, friends, and personal support organizations—can learn from model development and structure about the shared importance of the many intertwined stakeholders in helping to ameliorate the symptoms of PTSD. From a DoD perspective, such a framing model can justify the allocation of government resources to family, friends, and supporting organizations outside the DoD, as these are also seen as critical in a comprehensive treatment program.

We should clarify that no models perfectly depict reality, and they are used to describe reality as best as they can. As George Box and Norman Draper famously wrote, “All models are wrong, but some are useful” (Box and Draper 1987). Also, detailed models do not necessarily imply greater or even equal usefulness as compared to small or simple models. Here a quote often attributed to Albert Einstein is appropriate: “Everything should be made as simple as possible, but not simpler.” We have tried to follow these two propositions in our three developed models, which we describe next.

Three PTSD Models

Model I: A Conceptual Systems Model of PTSD

With what we refer to as Model I (developed as part of the innovation project), Ghaffarzadegan and Larson (2015) developed a qualitative representation of the system, seeking to answer a basic question: What are the interrelations among psychological, sociological, and medical factors in PTSD treatment? We think that a qualitative approach to the problem can be the first step in major modeling projects which will lead to better understanding of interconnections within a system and an overall map of the current state of the literature, and can lead to more accurate quantitative modeling efforts in the next stages.

Method The modeling effort at this stage was consistent with the procedures described in qualitative approaches to system dynamics modeling such as in

Luna-Reyes and Andersen (2003) and later in Kim and Andersen (2012). We used textual data: published articles and reports about PTSD in the military and the Department of Veterans Affairs. We carefully coded the discussion and conclusion sections of the papers on factors that influence PTSD treatment, trying to elicit causes and effects. Early in the coding effort, we recognized that causal factors affect PTSD treatment at three different levels (themes): Individual barriers, family and close friends' supports/barriers, and societal forces. This led to categorizing the effects under these three groups. Additional causal links were proposed to clarify causalities. Then the model was presented at different events with experts in both systems modeling and PTSD which further helped us clarify the model and make it more consistent with the domain experts' language. With this model, we uncovered several root causes that contribute to the complexity of treating PTSD.

Outcomes The main outcome of the study was a model to present an overall picture of the system. The model demonstrates how military personnel with PTSD are situated in a complex web of partially overlapping structures, some formal, such as those operated by the Department of Defense (and the VA), and some informal, such as those provided by family and friends. The model represents PTSD treatment as influenced by medical, personal, and social factors. This creates multi-layer dynamics. The individual layer concerns how personal decisions and willingness to seek care affect treatment.

Let us first start with corrective mechanisms. In an ideal situation, we would expect patients to seek care as soon as an individual becomes aware of PTSD symptoms, which leads to PTSD treatment and mitigation of symptoms (loop B1). In the family and friends layer, others may provide social support and help in treatment. With more support from family and friends, a patient can heal in a faster pace (loop B2). In addition, family and friends may encourage patients to seek care, e.g., spouses who not only support their ill spouse but also encourage them to see a doctor (loop B3). These are all idealistic corrective mechanisms which one hopes help cure the illness. Figure 1 shows these mechanisms.

However, the real world is much more complex. There is no guarantee that everyone will receive family and friend support. Furthermore, delaying treatment may lead to increase in illness and symptoms. Let us describe two major vicious cycles which inhibit treatment.

First, the illness can cascade and patients' mental and physical health may get worse if they do not receive timely treatment. Studies indicate that some PTSD patients also develop other psychiatric disorders (Najavits et al. 2009). Such increasing complications render medical interventions progressively less effective. Patients' responses in the form of drug abuse can further complicate health conditions. The entire process ends up in a cascading pattern that eventually converts mild medical illnesses into chronic and life-threatening conditions. This is shown with loop R1 in Fig. 2. Second, cascading illness happens due to isolation from family and friends over time. Figure 2 demonstrates two reinforcing loops of R2a and R2b to depict the tolerance limitation of close friends and family members. At higher levels of PTSD extent and symptoms, when patients significantly affect their family members, they

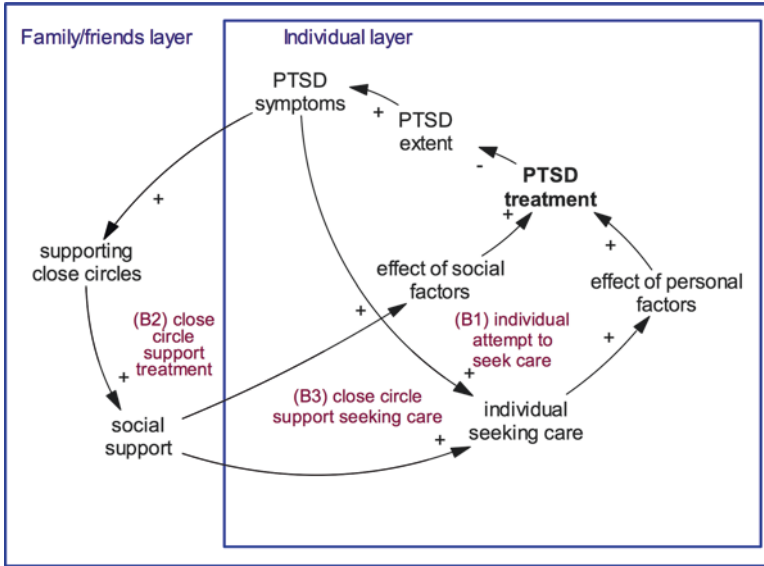


Fig. 1 Three corrective mechanisms for PTSD treatment

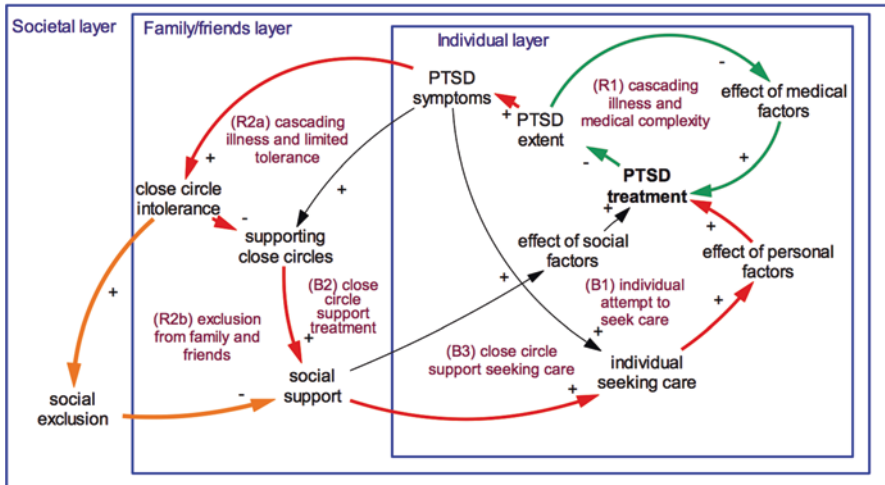


Fig. 2 Cascading medical complexities (loop R1) and isolation (loops R2a and 2b)

lose their social support and therefore get further excluded from the society. A simple example is not being invited to social gatherings, and more serious examples are workplace discrimination, losing a job, or having difficulties renting an apartment.

All of these effects ultimately feed back to the individual layer and adversely affect treatment and willingness to seek care.

These mechanisms are examples of vicious cycles. In this context, a vicious cycle is a feedback loop that, over time, creates cascading negative influences on PTSD sufferers and exacerbates their mental health situation.

We continued the development of the model and uncovered three more vicious cycles for PTSD treatment (see R3–R5 in Fig. 3). In summary, the five cycles are titled:

- R1—cascading illness and medical complexity
- R2—cascading illness and isolation from family and friends
- R3—stigma and social exclusion
- R4—self-fulfilling prophecy
- R5—the malingerer stigma

Additional information about these cycles can be found in Ghaffarzadegan and Larson (2015).

Overcoming vicious cycles is very difficult, requiring policies and patience over the long term. Without early interventions, these cycles result in an individual’s downward spiral into depression, family discord and possible divorce, substance abuse, joblessness, homelessness, and even suicidal ideation or action.

Like a snowball that gets bigger and bigger as it rolls downhill, vicious cycles are difficult to stop as they gain momentum. This analysis points to the need to prevent these situations from developing. Two conceivable policy steps are early effective screening and resiliency-related interventions (e.g., better recruitment procedures and resiliency-related training), where attention should be paid to military personnel and their families. Generally, resilience reflects the ability to maintain a stable equilibrium in highly disruptive events, such as loss of a close relation or life-

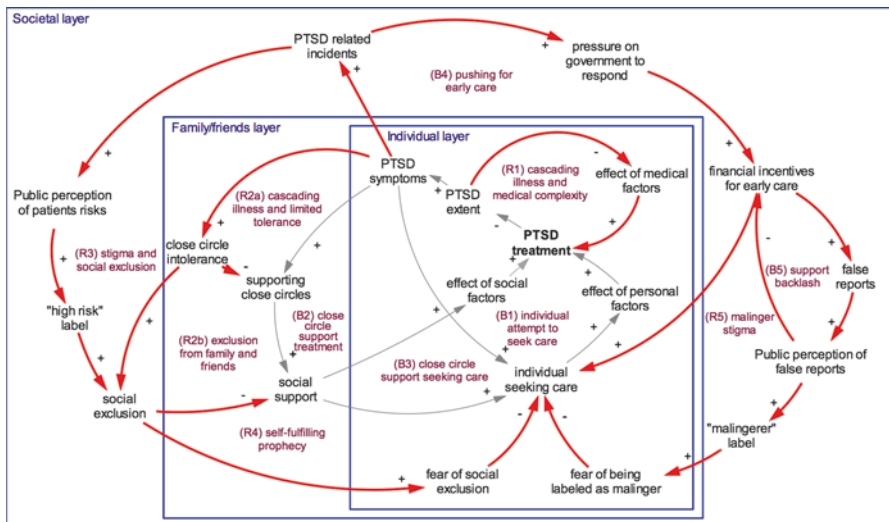


Fig. 3 A conceptual model of PTSD treatment. Adapted from Ghaffarzadegan and Larson (2015)

threatening situation (Bonanno 2004). Analyses on the veterans of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) show that unit support and post-deployment social support are some of the effective interventions that may increase resiliency (Pietrzak et al. 2010). Another approach is to help increase stress tolerance capacity through specialized training sessions for military personnel before deployment or immediately after experiencing a traumatic event (Department of the Army 2009).

Model I was a first step in framing the problem and understanding interconnections and complexities surrounding military personnel with PTSD. Next, we needed models to help quantify these effects and compare and contrast the effects of improving resiliency and early treatment. Such quantitative models should include uncertainties in diagnosis, individual health, access to care, and military personnel readiness. The models should also help compare PTSD prevalence and healthcare system costs under different policies and scenarios.

In response to these requirements, two additional models were developed for the project: a system dynamics model of PTSD prevalence and a Monte Carlo simulation model of an individual serviceperson.

Model II: A Population-Level System Dynamics Model of PTSD

With Model II, we moved toward quantifying the effects of different interventions on PTSD prevalence, asking these basic questions: What are the trends in the population of PTSD patients among military personnel and veterans? What policies can help mitigate the effects of PTSD? What are the healthcare cost implications of these policies?

Method To answer these questions, Ghaffarzadegan et al. (2016) developed a system dynamics simulation model of the PTSD population with a broad boundary, where the model incorporates both military personnel and veterans. It encompasses veterans of pre-2000 wars and more recent wars in Iraq and Afghanistan, and can track cases over the entire lives of patients. The overall structure of the model is developed in a way that simply—while as precisely as possible—presents the flow of individuals in the military and post-military and across different stages of developing the illness, diagnosis and treatment. In other words, our simple model captures the core mechanisms of a complex system. The model's equations are fully documented—along with the coding and time series—for further development and assessment (see the supplementary materials in Ghaffarzadegan et al. (2016) for more detail).

The model uses a variety of data sources. The structure is informed by the researchers' prior work, as well as other published articles and reports. The model parameters and time series (2000–2014) come from the DoD, the Institute of Medicine, and the VA. We ran the model for the period 2000–2025, where 2000–2014 was used for model validation and examination of the model's fidelity in

replicating the historical data. Then, the model forecasts the period 2015–2025. To create scenarios for forecasts, US involvement in wars and the intensity of future wars (in comparison to OIF) were used as inputs. The outputs are PTSD prevalence, number of PTSD cases diagnosed and undiagnosed in both the military and the VA, and PTSD-related healthcare costs.

Structurally, Model II depicts the flow of people from recruitment into the military, from the military to the post-military stage, and from the post-military stage to death. Figure 4 presents the stock and flow structure of the model, where a stock represents accumulation in the system and a flow is the rate at which the stock is changing. Let us briefly discuss these stocks and flows.

Flow (1) presents the recruitment of individuals, the majority healthy, who enter the ‘Healthy Military members’ stock; however, a small percentage might already have a history of PTSD and enter the ‘Ill-Undiagnosed Military members’ stock. As a result of traumatic events, healthy people in the service may develop the illness (Flow (2)) and move to the ‘Ill-Undiagnosed Military members’ stock. These undiagnosed individuals are either diagnosed with PTSD during their service (Flow (3)), or separated from the military with unknown illness (Flow (6)). Moreover, if ‘Ill-Diagnosed Military members’ are successfully treated (Flow (4)), they move back to the ‘Healthy Military members’ stock.

A similar diagnostic process also exists for veterans, where individuals in the ‘Ill-Undiagnosed Veterans’ stock are diagnosed with PTSD (Flow (8)) and moved to the ‘Ill-Diagnosed Veterans’ stock—these two stocks are fed by Flows (6) and (7), respectively. The last stock is ‘Healthy Veterans,’ which includes healthy individuals separated from the military (Flow (5)) and the successfully treated veterans (Flow (9)). It should be noted that all stocks in Fig. 4 have an outflow of death—the death rates are different for each stock, e.g., the death rate of healthy military members and that of healthy veterans are not the same. The death outflows are shown in grey.

For the sake of presentation, Fig. 4 contains a simplified version of the model and only illustrates the stock-and-flow structure. See Ghaffarzadegan et al. (2016) for more detail on the causal relationships among the variables that are key components of any system dynamics model. The model also incorporates the chances of deployment, experiencing trauma, and developing PTSD given that trauma. In the model, individuals do not necessarily reveal PTSD symptoms immediately; the diagnosis may be delayed, in some cases occurring after separation from the military. It should be also noted that since the model includes two subsystems, military and post-military, it helps estimate PTSD-related healthcare costs for both the DoD and the VA.

Outcomes Figure 5 is an example of one of the outputs of Model II. It depicts simulation outcomes of the model for the time period of 2000–2025. The time period can be divided into time frames of the past (2000–2014) and the future (after 2014). For the first time period, the goal was to replicate the data as a validation process, and the model fairly replicates the data.

For the post 2014 period, we assume three different scenarios about US involvement in future wars and estimate PTSD prevalence under these scenarios. In the first and second scenarios which are optimistic, the US deploys 1 and 2% of its troops to

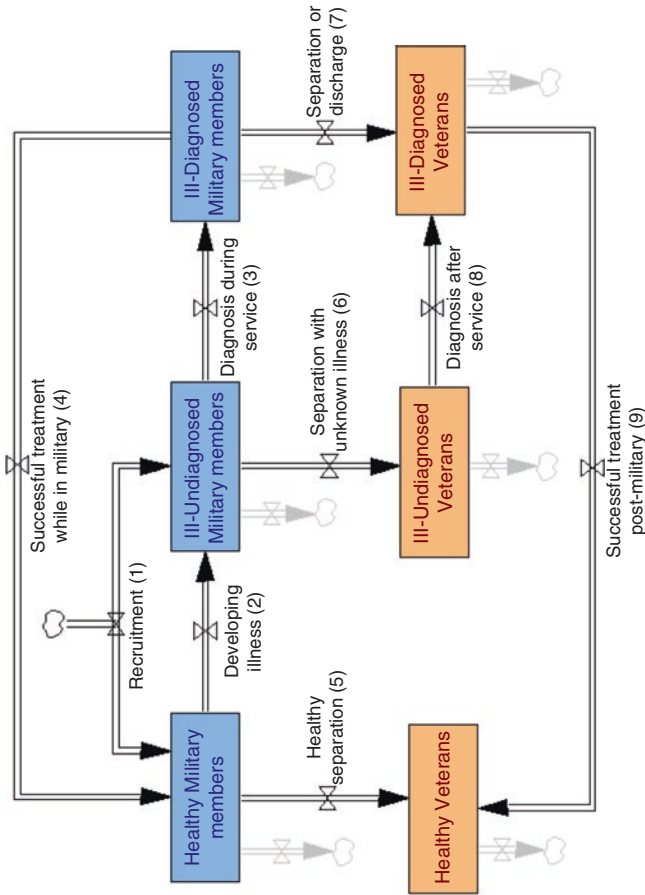


Fig. 4 A simplified version of Model II representing stocks and flows in the system. The *blue boxes* ('stocks') represent the military subsystem, and the *orange boxes* represent the post-military subsystem. Variables (1) through (9) are the main 'flows' in the system. All stocks in the model have an inflow (shown in grey) which represents death. For the sake of simplicity in this presentation, causal relationships among the model variables are not illustrated (see Ghaffarzadegan et al. (2016) for more detail)

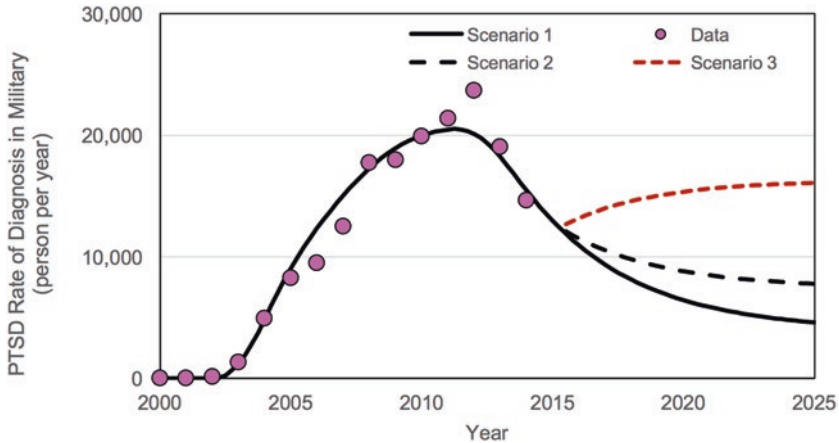


Fig. 5 PTSD diagnosis rate in the military [new cases per year]. Note: The model fits the available historical data for 2000 to 2014 and predicts the trends for 2015 to 2025 for three scenarios: Scenario 1: Minimum deployment to intense/combat zones (1% of military personnel); Scenario 2: 2% deployment to intense/combat zones; and Scenario 3: 5% deployment to intense/combat zones. Adopted from Ghaffarzadegan and Larson (2015)

combat zones. In the third scenario which is less optimistic, the US deploys 5% of the troops to combat zones. As a reference, in the Iraq and Afghanistan wars, deployment was around 8–10%. As the model shows in the optimistic scenarios, PTSD diagnosis per year will be around 5000–8000 new patients per year only in the military. This of course has implications for the population of veterans as well. Based on these estimations the model predicts that (not shown in the Figure), in scenarios 1 and 2, PTSD prevalence among veterans in 2025 will be about 10%.

The model yielded several major results, and we invite interested readers to refer to Ghaffarzadegan et al. (2016) paper. In sum, the model predicted that the population of patients and system costs will be very sensitive to US involvement in future wars, and that screening and treatment policy interventions will have marginal effects in comparison. In fact, more screening increases healthcare costs by increasing demand for health services. Furthermore, they find that it takes a long time, on the order of 40 years, to overcome the psychiatric consequences of a war. This is also consistent with the data on Vietnam-War-era PTSD patients.

Ghaffarzadegan et al. (2016) also provide detailed discussions about direct healthcare costs for the DoD and the VA related to PTSD. In reality, there are also social costs associated with PTSD, but these were not considered in the analysis. In an optimistic scenario (about 1 to 2% deployment to intense/combat zones in the next 10 years), the model's predictions of PTSD healthcare costs for the military in 2025 range from \$130 to \$160 million per year (in 2012 dollars). With greater involvement in future wars (about 5% deployment to intense/combat zones), the costs potentially increase to \$260 million per year. For the VA, the cost estimates are one order higher, with average estimates of \$2.9–\$3.2 billion per year (in 2012 dol-

lars). With greater involvement in future wars (5% deployment to intense/combat zones), this cost can also increase to \$3.6 billion per year.

One major outcome of this modeling effort which has policy informatics implications is its “management flight simulator.”

Similar to the airline industry, in that no pilot is sent up in a jumbo jet without enough training in a flight simulator, policy makers should also not make a major decision based only on their knowledge and experience. Management flight simulators provide a virtual “gaming” environment for policy experiments, where policy and decision makers can explore the effects and consequences of their decisions over the long haul.

Our flight simulator helps represent the model outputs in an interactive interface and easy-to-interpret fashion, such that users are not required to use any specific software or be familiar with any modeling language. More importantly, it brings an experiential aspect to learning about the complexity of the system. Similar applications have been developed in other fields, such as People Express in strategic management (Sterman 1992), Climate Interactive (C-ROADS) in climate change (Sterman et al. 2012), and ReThink Health in health policy (McFarland et al. 2016). Our simulator can be tried online at <http://jalali.mit.edu/ptsd-simulation>. Figure 6 provides a snapshot of the online presentation of the simulator.

Beyond prevalence and cost estimates, as well as providing a flight simulator, one major insight from developing Model II is the importance of considering PTSD as a multi-organizational problem. A systematic approach to PTSD needs to consider the military and post-military stages together, since an effective policy in one stage may create problems for the other. The models should also look at long-term dynamics, considering delays between developing PTSD and showing symptoms. The analysis also shows that a focus on resiliency and decreasing the chances of developing PTSD is potentially one of the most effective policies, which is consis-

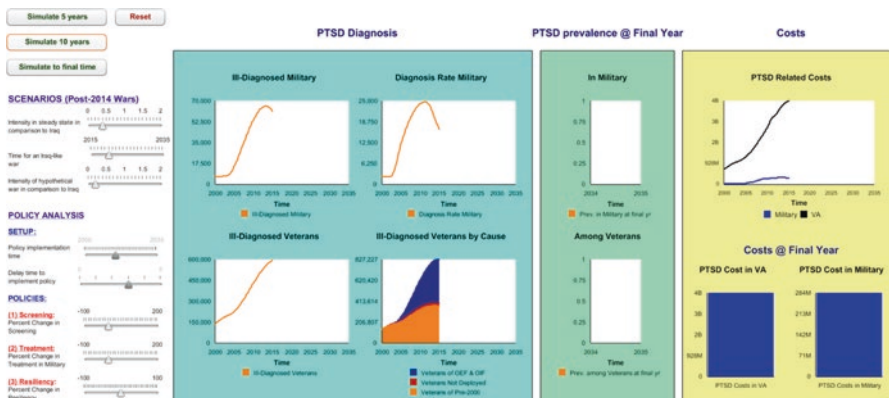


Fig. 6 Snapshot of the online presentation of Model II, available at: <http://jalali.mit.edu/ptsd-simulation>

tent with Model I's suggestions. As stated before, resiliency is about increasing the ability to maintain stable emotions in disruptive events (Bonanno 2004). In our case, increasing resiliency can be achieved by, e.g., immunizing individuals against PTSD with more support and psychological training sessions (Department of the Army 2009; Pietrzak et al. 2010).

Model III: A Monte Carlo Simulation Model of PTSD

Model III is a Monte Carlo simulation model developed by Fingerhut (2015). It predicts PTSD and associated clinical demand over five decades following OEF and OIF.

This approach creates representative service members who replicate the deployment schedule, PTSD risk, care-seeking behavior, and treatment of actual service members from the two conflicts. After randomly assigning each virtual service member's deployment and trauma exposure, as well as possible PTSD onset, recognition, and treatment events over the period of study, the study aggregates each individual's simulated history to determine population level statistics and trends. This study also provides a series of sample policies designed to replicate possible decisions that policy makers could implement to affect burden posed by PTSD.

The model uses empirically observed distributions of parameters from across the mental health care system (traumatic exposure, onset, recognition, care-seeking, and treatment) to estimate the dynamic trends of a series of individual and population level variables.

Method The model simulates a population of service members deployed to Iraq and Afghanistan. In this model, an individual's use of clinical resources depends on the individual's PTSD symptoms, PTSD recognition status, and treatment characteristics. The model is stochastic and each simulated service member is followed over the length of the study. The model also uses quarterly data for the 2003–2014 period on the total number of deployed troops and average troop rotation rates. The basic algorithm is as follows:

1. Each simulated service member may develop PTSD after each deployment with a probability that varies as a function of combat severity and duration.
2. For the simulated service members who develop PTSD, the timing of the first symptom onset and the frequency at which PTSD is re-experienced are generated randomly.
3. In each period, a simulated service member may be recognized with a possible PTSD case with a probability that is a function of time since trauma.
4. Service members with a recognized cases of PTSD may seek care with a probability that is a function of time since recognition of symptoms.
5. A treatment is successful at remitting the service member's PTSD symptoms with a probability that depends on treatment efficacy and the probability of treatment drop-out.

All the values mentioned here are extracted from empirical studies in the psychology literature. Further details regarding the model structure, parameter derivation, and results are available in Fingerhut (2015).

The model manipulates a time-series form of input and is thus able to provide time-series output. That output takes the form of prevalence estimates from the population perspective, that is, each point in calendar time provides a snapshot of what a real-world population prevalence estimate would look like, given changes in deployment, combat, and other factors over time.

Outcomes The model projects a peak rate of active-case PTSD of about 200,000 by 2016 (17% of the deployed population) which later declines to 150,000 by 2025 (15% of the population). These predictions reflect best-case assumptions about PTSD recognition, care-seeking, and treatment efficacy observed in recent empirical studies. This model further predicts that 29% of OEF/OIF combat veterans will experience PTSD at some point in their lives (Fig. 7).

In terms of care-seeking and treatment, under best-case care-seeking assumptions, Model III predicts that 80% of the ever-PTSD population (the population that at somepoint in their life suffer from PTSD) will seek treatment. The model estimates that 48–63% of the ever-PTSD population (14–18% of the OEF/OIF population) are expected to seek treatment. Under best-case model assumptions, clinical demand peaks at 3% of the OEF/OIF population per year in 2010, decreasing to 0.5% of the OEF/OIF population in 2025.

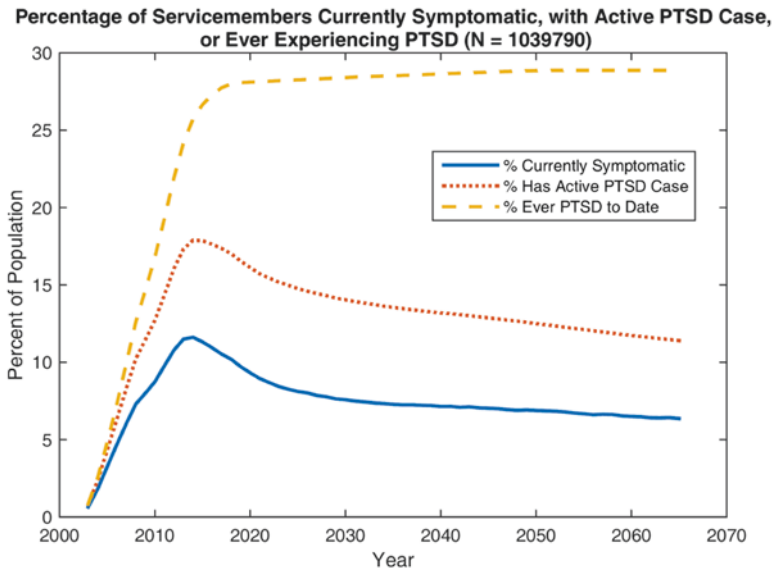


Fig. 7 Baseline (best-case) model predicted percent of service members with currently symptomatic or active case PTSD in each year and service members who have ever experienced PTSD through the indicated year end. Percentage denominator is the number of deployed service members in the indicated year. Figure is adopted from Fingerhut (2015)

Discussion and Conclusions

The three models specific to the innovation project are initial efforts to depict (in a systems context) our knowledge about PTSD treatment system structures. The models embed the all-important psychological and social processes, both formal and informal, underlying the PTSD burden in the populations studied. They provide a good first look at the implications of various policies and managerial actions on future prevalence of PTSD, clinical demand, and costs. For those interested in additional details, each model is fully developed in separate published papers and/or technical reports, as cited in this chapter and in the references.

In this chapter, we aimed to synthesize the models, and provide a systems level perspective on these modeling efforts. The models provide examples of how different modeling techniques that utilize a wide range of qualitative and quantitative data sources can help analyze a major health issue and inform policy makers. We would also like to stress the interconnections between all these modeling efforts. For example, we see how a qualitative model (Model I) leads to a quantitative model (Model II) which raises further questions at the individual level that can be investigated in an agent-level model (Model III). There is no single model that can answer all questions, but we gain insights in the process of modeling, and resolving research questions may lead to further questions that will need more modeling efforts. In a sense, model-based policy informatics as a process is not a linear set of actions but includes the cycle of problem recognition, data gathering, model building, insight generation, and more problem recognition. During the policy informatics process, we are “inform”ed by different data sources and models, and we address additional “policy” challenges.

We also want to stress the importance of models when dealing with huge datasets. Extracting insights from big data requires good models. While larger datasets sound helpful, it is important to not fall into the trap of losing the big picture. And as was discussed in this chapter, models come in different forms and are developed for various purposes.

In this chapter, we also offered an example of a flight simulator. As discussed, Model II was further developed to allow policymakers to easily “play” with the model and test the effects of different policy measures. Ultimately, the goal of the modeling projects was to inform policy makers, but the main challenge is about helping them learn, question, and trust the model outcomes. Given that policy makers often come from a wide range of fields and backgrounds, they might not be familiar with the technical languages of modelers; hence, the modeling projects may not be fully understood or used by the policy makers. Flight simulator platforms are critical tools in this respect which provide a simple and non-technical environment to present the model outcomes clearly and help the policy makers focus on the meaning of the outcomes rather than how to run the models.

Furthermore, the chapter aims to depict how, under the umbrella of policy informatics, different modeling techniques can provide different levels of insight about a major societal problem.

While the discussed models are different in many respects, they share two major methodological themes. First, they take systems approaches. Most previous models of mental health in the military or the VA have a very narrow perspective and focus exclusively on either the military or the VA. A narrow focus on one organization “shifts the burden” to the other organization. Furthermore, most past models take a snapshot of the problem and focus on solving “today’s issues.” Second, the models presented here were informed by a wide range of qualitative and quantitative data. Model I is rooted in qualitative data, and models II and III are calibrated with multiple data sources.

Going forward, two key questions remain. First, *how might these models be used?* Our suggestion is to view the models as living entities, evolving and improving over time as new knowledge becomes available. This will require professionals in the DoD and VA to take ownership of the models and incorporate model related information in a timely fashion as it becomes available.

Second, *what is the take-away?* The models show the effects of changes ranging from administrative aspects such as multi-year projected budget levels that may constrain system resources, to new scientific knowledge about the efficacy of new treatments for PTSD. Within the models, budget constraints may appear only indirectly in terms of the total numbers of professionals and facilities available for PTSD treatment. Understanding the impact of putting new scientific knowledge to work will require going into the details of the models, feedback loops, flow parameters, response delays, and updating them to be compatible with the new scientific results. New science will, in turn, affect budgets and facilities. Perhaps a new treatment protocol will prove very costly, but demonstrate a very high chance of lifetime cessation of PTSD symptoms after, say, 2 years of the treatment. Such a protocol if discovered, would likely be expensive in the short term but very cost-effective in the long term. All this shows how scientific knowledge of treatment effects could cause major changes in the DoD resource-intensive systems model.

One final thought: Our observation, not only for the DoD but also for the VA and virtually all large service systems (including research universities), is that everyone is so dedicated to their work that on a day-to-day basis they often only “see” the immediate vicinity of their own workplaces. Improvements—some may call them “optimizations”—tend to be local that is, focused only on that small part of the total system in which a group of professionals works. One major value of systems models is that they show how one set of changes affects many aspects of a complex structure. They demonstrate clearly the hazards of local optimization, showing how even attractive local changes have the potential to be detrimental to the total system. In this sense, systems models provide an integrated, unifying framework that can enable key policy makers throughout the system to discuss their problems intelligently and objectively. This attribute may be one of the major arguments in favor of systems models.

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