

STUDY PROTOCOL

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# An effectiveness-implementation hybrid trial study protocol targeting posttraumatic stress disorder and comorbidity

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## Abstract

**Background:** Each year in the USA, 1.5–2.5 million Americans are so severely injured that they require inpatient hospitalization. Multiple conditions including posttraumatic stress disorder (PTSD), alcohol and drug use problems, depression, and chronic medical conditions are endemic among physical trauma survivors with and without traumatic brain injuries.

**Methods/design:** The trauma survivors outcomes and support (TSOS) effectiveness-implementation hybrid trial is designed to test the delivery of high-quality screening and intervention for PTSD and comorbidities across 24 US level I trauma center sites. The pragmatic trial aims to recruit 960 patients. The TSOS investigation employs a stepped wedge cluster randomized design in which sites are randomized sequentially to initiate the intervention. Patients identified by a 10-domain electronic health record screen as high risk for PTSD are formally assessed with the PTSD Checklist for study entry. Patients randomized to the intervention condition will receive stepped collaborative care, while patients randomized to the control condition will receive enhanced usual care. The intervention training begins with a 1-day on-site workshop in the collaborative care intervention core elements that include care management, medication, cognitive behavioral therapy, and motivational-interviewing elements targeting PTSD and comorbidity. The training is followed by site supervision from the study team. The investigation aims to determine if intervention patients demonstrate significant reductions in PTSD and depressive symptoms, suicidal ideation, alcohol consumption, and improvements in physical function when compared to control patients. The study uses implementation science conceptual frameworks to evaluate the uptake of the intervention model. At the completion of the pragmatic trial, results will be presented at an American College of Surgeons' policy summit. Twenty-four representative US level I trauma centers have been selected for the study, and the protocol is being rolled out nationally.

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**Discussion:** The TSOS pragmatic trial simultaneously aims to establish the effectiveness of the collaborative care intervention targeting PTSD and comorbidity while also addressing sustainable implementation through American College of Surgeons' regulatory policy. The TSOS effectiveness-implementation hybrid design highlights the importance of partnerships with professional societies that can provide regulatory mandates targeting enhanced health care system sustainability of pragmatic trial results.

**Trial registration:** ClinicalTrials.gov NCT02655354. Registered 27 July 2015.

**Keywords:** Traumatic injury, Multiple chronic conditions, Posttraumatic stress disorder, Depression, Suicidal ideation, Substance abuse, Effectiveness-implementation hybrid, Pragmatic clinical trial, American College of Surgeons, Policy

## Background

The overarching goal of the trauma survivors outcomes and support (TSOS) effectiveness-implementation hybrid clinical trial is to develop and implement a large scale, cluster randomized pragmatic demonstration project that directly informs national trauma care system policy targeting injured patients with presentations of posttraumatic stress disorder (PTSD) and related comorbidity. Physical injury occurs frequently in the USA and constitutes both a substantial source of individual suffering and a significant public health burden. Each year in the USA, over 30 million individuals present to acute care medical trauma center and emergency department settings for the treatment of traumatic physical injury [1–5]. Injured trauma survivors present to acute care medical settings after both intentional (e.g., gunshots, stabbings, physical assaults) and unintentional (natural disasters, motor vehicle crashes) injury events [6]. Annually, 1.5–2.5 million Americans are so severely injured that they require inpatient hospitalization [1–5]. Estimates suggest that approximately 1.5 million American youth and adults experience traumatic brain injury (TBI) annually [7, 8]. Physical injury with and without TBI constitutes a major public health problem for both civilian and veteran patient populations [9, 10]. Globally, traumatic injury accounts for approximately 16 % of the world's burden of disease [11–13].

Multiple chronic conditions appear to be endemic among physical trauma survivors treated in US trauma care systems [14–16]. Recent commentary has explicated chronic conditions as conditions that last 1 year or more and require ongoing medical attention and/or limit activities of daily living [17–19]. Highly prevalent comorbidities include enduring PTSD, depression, and associated suicidal ideation, alcohol, and drug use problems, TBI, and chronic medical conditions such as hypertension, coronary artery disease, diabetes, and pulmonary disease [14, 20, 21].

Evidence-based, collaborative care intervention models for PTSD and related comorbidities exist [16, 22–25]. Collaborative care treatment models however, have yet to be broadly implemented throughout US trauma care systems; prior investigation by members of the interdisciplinary

study team suggest that less than 10 % of US trauma centers routinely provide post-injury screening or integrated care management treatment targeting the cluster of PTSD and related comorbidities [26]. The enduring challenges presented by the chronic disease cluster of PTSD and comorbidities after injury require innovative research approaches that cut across the traditional domains of multiple NIH institutes (<https://www.nihcollaboratory.org>).

The investigation is designed as an effectiveness-implementation hybrid pragmatic trial that simultaneously aims to assess the treatment outcomes of the collaborative care intervention targeting PTSD and comorbidity, while also assessing the potential utility of the implementation strategy [27]. The study aims to determine if injured patients receiving the collaborative care intervention demonstrate significant reductions in PTSD symptoms when compared to control patients receiving care as usual. The study also aims to determine if intervention patients, when compared to control patients, will demonstrate significant reductions in depressive symptoms and associated suicidal ideation, alcohol use problems, and improvements in physical function.

Over the past decade, the study team has established a stakeholder partnership with the American College of Surgeons' Committee on Trauma, whereby the results of pragmatic comparative effectiveness trials can be directly translated into policy mandates and best practice guidelines for the regulation of US trauma care systems [26, 28–31]. The investigative team will employ implementation science conceptual frameworks to better understand the potential uptake of the intervention model by trauma care systems nationwide.

## Implementation science and randomized clinical trial conceptual frameworks informing the TSOS trial

Recent commentary has noted a proliferation of models and conceptual frameworks that can potentially inform the design of investigations that target the widespread dissemination and implementation of health care interventions; in reviewing this literature, commentary suggests

a systematic selection of optimal approaches for a particular investigation or health care delivery system [32–34].

By necessity, multiple theoretical and applied perspectives inform the conceptual framework underlying the TSOS pragmatic trial design and implementation [32] (Fig. 1). The TSOS pragmatic trial design and implementation incorporates implementation science evaluation frameworks [35], and classic theories [36], as well as frameworks that address sustainable health care system change [37, 38]. The TSOS study is also informed by effectiveness-implementation hybrid design [27], pragmatic trials [39], and stepped wedge [40–43] clinical trial design considerations.

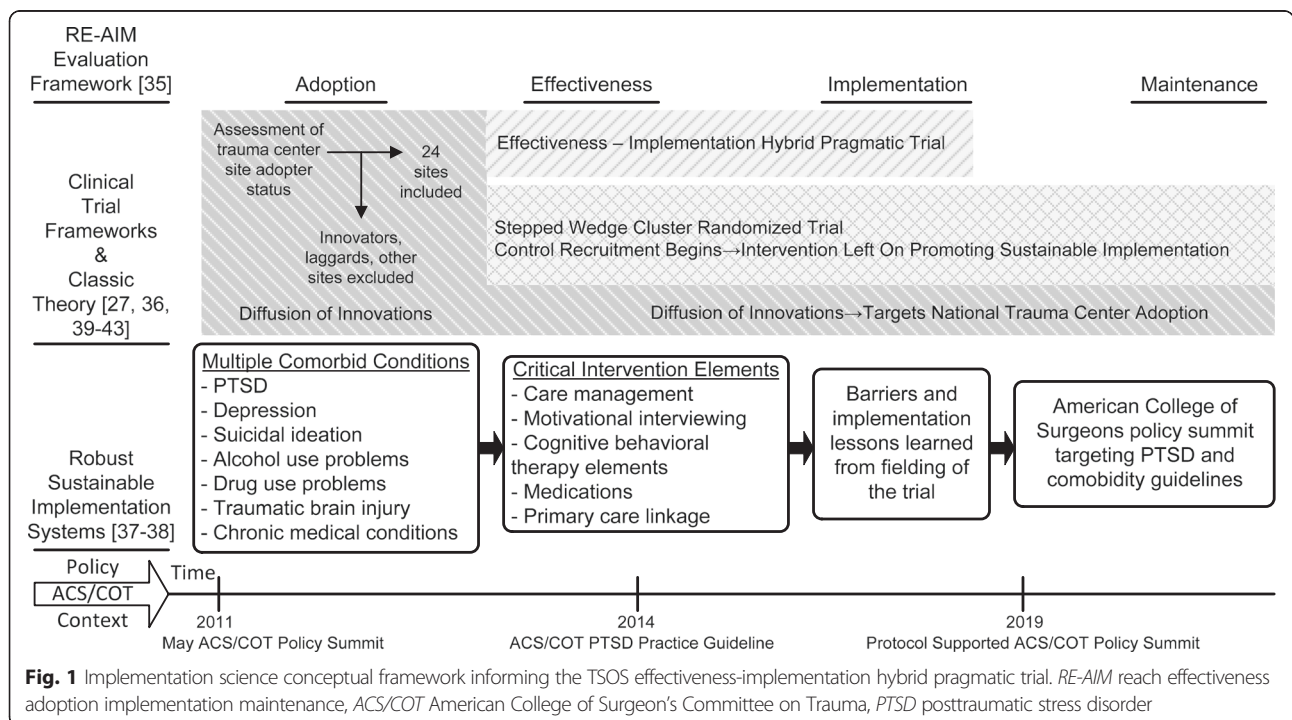
The implementation science conceptual frameworks influencing study design begin with the reach effectiveness adoption implementation maintenance (RE-AIM) evaluation framework that outlines clear stages of assessment for both effectiveness and implementation outcomes (Fig. 1). The RE-AIM framework provides a model for the integration of pragmatic trial results into routine trauma center practice [37]. Diffusion of innovation theory, which emphasizes the factors related to the intervention and setting characteristics, aids in the framing of the population-based sampling and adoption of trauma centers as well as descriptions of maintenance, based on the trial's ability to target American College of Surgeons' policy in order to shift "S-shaped" adopter curves nationally [36].

Clinical trial specific constructs and design features also contribute to the conceptual framework informing the TSOS study (Fig. 1). These include the emerging

effectiveness-implementation hybrid design construct [27]. The TSOS trial simultaneously aims to determine the effectiveness of the stepped collaborative care intervention model in reducing PTSD symptoms and comorbid conditions, while also assessing the potential utility of the implementation strategy that uses American College of Surgeons' policy to target regulatory mandates for trauma care systems nationally [37, 44].

The pragmatic-explanatory continuum indicator summary (PRECIS) pragmatic trial framework also informs the TSOS study [39]. Gold standards for pragmatic trial design and implementation include broad participant eligibility criteria, flexible intervention delivery, application by the full range of practitioners, and incorporation of rigorous prospective controls, preferably by randomization. Usual practice comparison conditions are frequently used in pragmatic trials [39, 44–48]. The optimal pragmatic trial is characterized by an intent-to-treat data analytic approach that includes all patients regardless of adherence [39]. The TSOS trial encompasses these pragmatic trial attributes by fielding a readily implementable collaborative care intervention that targets injured patients with the full spectrum of PTSD and related comorbidity with minimal exclusionary criteria.

Pragmatic trial process and outcome assessments have been conceptualized to be centrally measured, clinically meaningful, and require minimal adjudication [39, 44–48]. With regard to pragmatic trials in US trauma care systems, no one or even multiple administrative databases can be used to track outcomes among injured trauma



**Fig. 1** Implementation science conceptual framework informing the TSOS effectiveness-implementation hybrid pragmatic trial. RE-AIM reach effectiveness adoption implementation maintenance, ACS/COT American College of Surgeons' Committee on Trauma, PTSD posttraumatic stress disorder

survivors; thus for trauma care system pragmatic trials, scheduled telephone outcome assessments may by necessity occur as an addition to naturalistic follow-up. The PRECIS framework suggests that for some trials, outcome assessments must by necessity be obtained through contact with participants [39]. Similarly, the PRECIS framework takes into consideration the observation that in some trials that rely heavily on patient reported outcomes, some training in the assessment and adjudication may be desirable [39].

As an integrative model (Fig. 1), the Robust, Sustainable, Implementation Systems Framework [37] aids in combining the implementation science, pragmatic trial, and health care systems change conceptual frameworks that inform the TSOS study; conceptually the Robust, Sustainable, Implementation Systems Framework integrates elements of process and implementation models, determinant frameworks, and clinical trial frameworks (e.g., multiple comorbid condition targets and critical intervention elements) as well as the RE-AIM evaluation framework [32, 37] (Fig. 1). A further advantage of the framework is the flexible integration of recent work on barriers and facilitators of acute care medical screening and intervention guideline implementation ([49–51]). Policy relevance that ultimately enhances clinical trial population impact is also relevant to the Robust, Sustainable, Implementation Systems Framework [37, 52, 53]).

## Methods/design

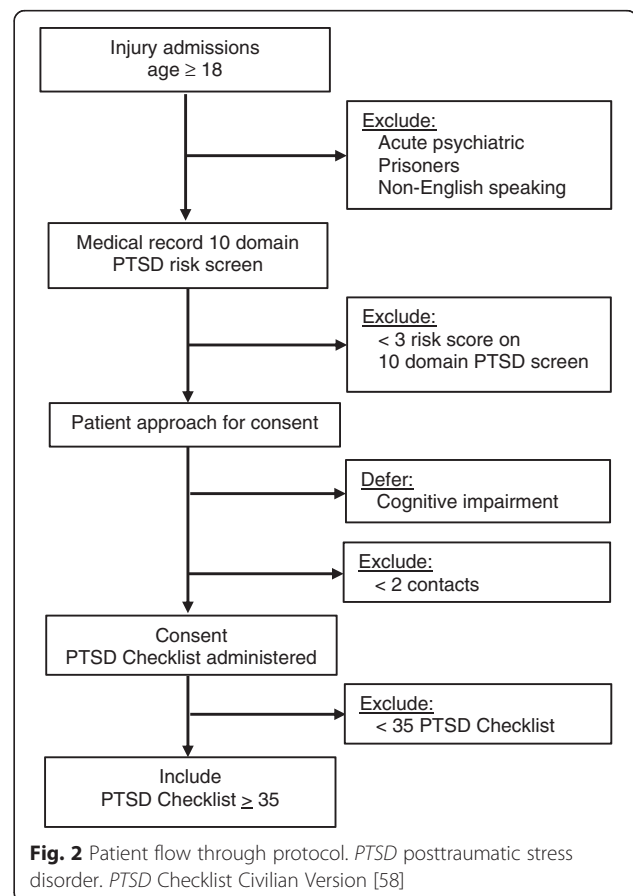
### Design overview

The TSOS trial aims to recruit 960 patients, 40 at each trauma center site. The TSOS investigation employs a stepped wedge cluster randomized design in which sites are randomized sequentially to initiate the intervention. Patients are assessed at baseline in the emergency department or as trauma inpatients and again 3, 6, and 12 months after the injury. All sites have worked with the study team to implement an electronic health record (EHR) initial PTSD risk evaluation. Patients identified by the EHR evaluation as high risk for PTSD are formally assessed with the PTSD Checklist for study entry. Patients in the control condition will receive enhanced trauma center care as usual. Patients in the intervention condition will receive a stepped collaborative care intervention targeting PTSD and related comorbidities. The intervention begins with a 1-day workshop training in the collaborative care intervention core elements that include care management, medication, cognitive behavioral therapy (CBT), and motivational interviewing targeting PTSD and comorbidity. After the 1-day workshop, the site will receive supervision from the study team. Outcome analyses will incorporate both effectiveness and implementation spectrum assessments.

### Injury cohort definition, exclusions, and PTSD risk screening

Prior to the initiation of recruitment for the TSOS study, the investigative team worked with each trauma center site to define injury cohorts, characterize inclusion and exclusion phenotypes within the EHR [54], and implement the 10 domain EHR PTSD risk screen [16, 55]. The procedures used to define injury cohorts and characterize potential emergency department and trauma inpatient subjects for the recruitment process varied across sites depending on the capacity of individual sites to automate the screening procedure within or external to the EHR [56]. The automated form of the evaluation can be performed using EHR data queries or scheduled reports, while the manual form of the abstraction procedure involves reviewing individual health records; many sites have combined automated and manual procedures into a partially automated (i.e., hybrid) 10-domain risk screen.

Injured patients of both genders over the age of 18 are included in the trial (Fig. 2). Prisoners and non-English speaking patients, will be excluded. Patients whose index injury was self-inflicted or are psychotic will receive immediate psychiatric treatment and will also be excluded from the trial. In order to assure adequate follow-up rates, patients must be able to provide two pieces of follow-up contact information.



Patients identified by EHR evaluation as at-risk for high early PTSD symptom levels with a score of >3 risk domains positive will then be formally screened for study entry with the PTSD Checklist Civilian Version [57, 58]. Patients scoring >35 on the PTSD Checklist will be followed longitudinally in the clinical trial portion of the investigation.

**Randomization**

Prior to initiation of patient recruitment, each of the 24 sites was randomized to one of four waves in the stepped wedge design. Each wave was assigned a specific proportion of control and intervention patient recruitment (Fig. 3). The study biostatistician randomized sites to waves using a computer generated algorithm. All interviewers conducting follow-up assessments will be blinded to patient intervention and control group status.

**Enhanced usual care control condition**

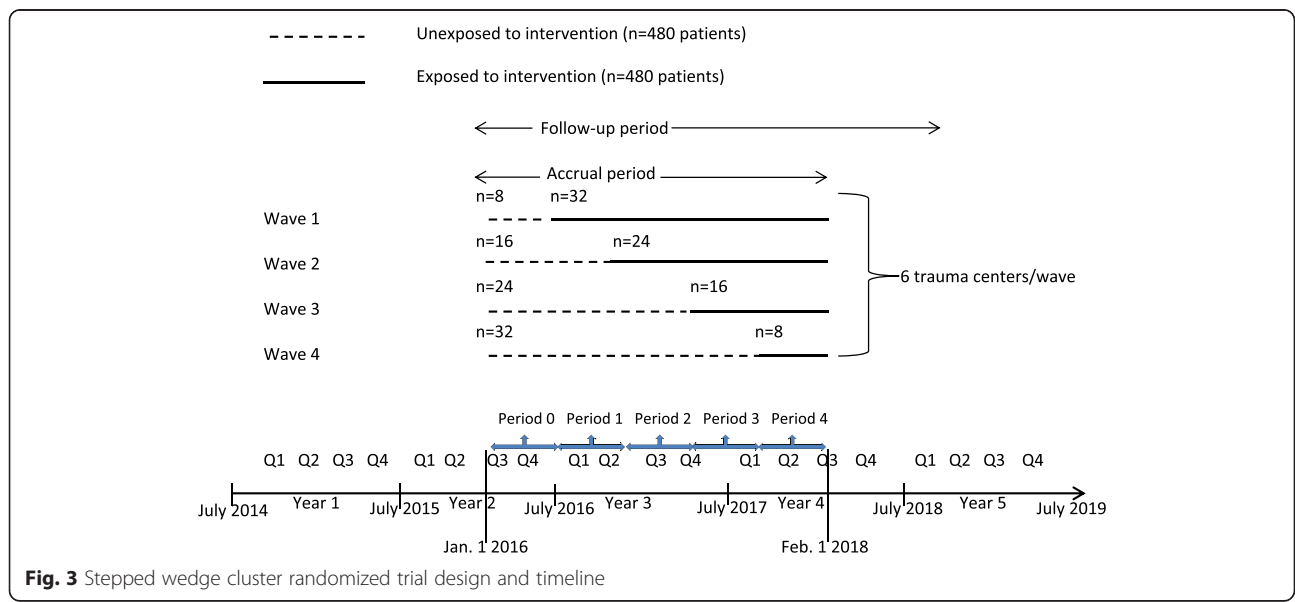
The control patient subjects will receive enhanced usual trauma center care. Prior investigation suggests that usual posttraumatic care includes routine surgical, primary care, and emergency department visits, as well as the occasional use of specialty mental health services. The enhanced aspect of the usual care will consist of the recruiting provider informing the ward nurse currently covering the patient subject’s care of any distress they are experiencing as identified by a PTSD Checklist score of >35 or Patient Health Questionnaire (PHQ-9) item 9 > 1 indicating suicidal ideation, administered during the baseline interview.

**Stepped collaborative care intervention [16, 22–25]**

Collaborative care treatment models that combine effective intervention elements and incorporate IT innovations have the potential to be flexibly implemented in order to prevent the development of the chronic condition cluster that includes PTSD and related comorbidity; collaborative care treatment models may also be effective in mitigating the impact of the acute injury event on symptom exacerbations in the large subpopulation of injury survivors who already carry a substantial pre-injury burden of chronic medical and other conditions [22, 25, 59–63] (Table 1).

A large body of research has established the effectiveness of integrated care delivery models such as collaborative care in reducing depressive, anxiety, pain, and other somatic symptom presentations in conjunction with comorbid medical conditions in primary care settings [22, 23, 25, 61, 64–78]. Collaborative care treatments bring together effective medication and psychotherapeutic intervention elements with care management strategies that target reductions in care fragmentation and enhanced care coordination for patients with multiple chronic conditions (Table 1). A series of single site acute care medical studies now support the effectiveness of collaborative care models in targeting the PTSD and comorbidity chronic condition cluster [16, 22–25].

Study staff will visit the trauma center sites in order to perform a 1-day intervention workshop training. The workshop will provide an overview of the core elements of the PTSD and comorbidity intervention (Table 1). The trainers will review the intervention elements including care management, medications, motivational interviewing (MI) and CBT elements, and community



**Fig. 3** Stepped wedge cluster randomized trial design and timeline

**Table 1** Core elements of collaborative care intervention targeting PTSD and comorbidity after injury

Essential element	Which disorders targeted	MCC strategic framework goals addressed <sup>a</sup>
Population-based EHR PTSD and comorbidity risk prediction	PTSD, depression, suicidal ideation, alcohol and drug use problems, TBI and chronic medical conditions after acute injury	Goal 1 objective D implement and efficiently use health information technology; EHR screening efficiently identifies constellation of PTSD and comorbidity in injured populations
Care management with trauma center to primary care linkage	Coordination of acute injury mental health and pre-existing chronic medical condition care	Goal 2 facilitate use of community based services and self-care management
Early post-injury medication history, reconciliation, and care coordination	PTSD, depression, pain, and TBI symptoms prevention. Chronic medical condition reconciliation and coordination	Goal 1 objective E prevent occurrence of new chronic conditions and mitigate the consequences of existing conditions Goal 2 objective C provide tools for medication management
Evidence-based MI embedded within care management	Targets alcohol and drug use problems and enhanced patient engagement	Goal 1 objective E prevent occurrence of new chronic conditions and mitigate the consequences of existing conditions
Evidence-based CBT embedded within care management	Targets PTSD, depression, pain, and TBI symptoms. Also targets enhanced patient self-efficacy	Goal 1 objective E prevent occurrence of new chronic conditions and mitigate the consequences of existing conditions Goal 2 objective A facilitate self-care management
Patient and caregiver-centered posttraumatic concern elicitation and improvement	Patient-centered concerns elicitation and improvement targets patient and family engagement in care of full MCC constellation	Goal 2 optimize self-care management and coordinated use of services by patient and caregivers
Caseload supervision and stepped measurement-based care implementation	PTSD, depression and associated suicidal ideation, alcohol and drug use problems, chronic medical conditions and acute physical injury	Goal 3 provide better information and education on treatment of MCCs to health care workers

MCC multiple chronic condition, EHR electronic health record, PTSD posttraumatic stress disorder, TBI traumatic brain injury, MI motivational interviewing, CBT cognitive behavioral therapy

<sup>a</sup>All study elements address MCC Goal 4 of Enhancing Research Knowledge on MCCs [17–19]

linkage. Specific intervention procedures have been detailed previously [16, 22–25].

After the 1-day workshop training, the study team will initiate regular site care management supervisory calls in which the site interventionists will present cases to the supervisory team [16, 79]. These sessions will include coaching in concern elicitation, CBT, and MI elements embedded within care management, as well as problem-solving barriers to screening and intervention implementation for PTSD and related comorbidity. These calls will also include coaching on evidence-based medication prescription and supervisory team written feedback. The care managers will be able to contact MD and PhD study team members on a 24-h study cell phone or study assistance email should more urgent questions arise. While final patient subject follow-up interviews take place approximately 12 months post-consent, intervention activities are anticipated to conclude approximately 6 months after patient subjects consent into the trial. During the final months of treatment, the interventionist will discuss with the patient strategies for maintaining treatment gains. This means proper handoff of medication prescription management to a patient subject's preferred primary care or other medical provider, linkage to community resources, engaging family and community support, and when indicated psychotherapy referrals.

## Assessments

The TSOS assessment approach incorporates both effectiveness and implementation outcome evaluations [80]. The timing and content of the TSOS outcome assessments are delineated in Tables 2 and 3. The primary effectiveness evaluations are patient-reported outcome measures that include assessments of the study primary and secondary outcomes (Table 2). The RE-AIM evaluation framework informs the implementation outcome assessments [35] (Table 3). Selected outcome assessments are described in further detail below.

- A. Primary study patient-reported outcome: PTSD symptom assessment [58, 81]  
The PTSD Checklist is a 17-item self-report questionnaire that will be used to assess PTSD symptoms. A series of investigations have demonstrated the reliability and validity of the PTSD Checklist across trauma-exposed populations. PTSD Checklist scores of >35 in the days and weeks after injury admission have been shown to be associated with the development of higher PTSD symptom levels over the course of the year after injury [55].
- B. Secondary study patient-reported outcomes: depressive symptoms, suicidal ideation, alcohol use problems, and physical function

**Table 2** Effectiveness assessments and timing of administration

Study measure	Baseline	3 months	6 months	12 months
EHR 10 item PTSD evaluation [55]	X			
ICD injury severity	X			
ICD TBI severity	X			
ICD/self-report chronic medical conditions	X	X		
EHR and self-reported demographics	X			
Consciousness/Glasgow Coma Scale [144, 145]	X			
PTSD (PTSD Checklist DSM-IV & DSM-5) [58, 81]	X	X	X	X
Depression (PHQ-9) [82]	X	X	X	X
Suicidal ideation (PHQ-9 item 9) [82, 84]				
Alcohol (AUDIT) [85]	X	X	X	X
Illegal and prescription drug use (DAST) [146]	X	X	X	X
Pain (Brief Pain Inventory) [147, 148]	X	X	X	X
Postconcussive symptoms [90, 149, 150]	X	X	X	X
Functioning (MOS SF12/36) [88]	X	X	X	X
Violence risk behaviors [24]	X	X	X	X
Pre-injury trauma [6, 106, 107]		X		
Recurrent traumatic events [6, 106, 107]			X	X
Reactions to research participation [25]	X	X	X	X
Satisfaction with care [16, 25]	X	X	X	X
Health services, work and cost [14, 151–154]	X	X	X	X
Medication use [14, 16, 25, 151]	X	X	X	X
EHR/trauma registry data [14, 151]	Ongoing automated data			

*EHR* electronic health record, *PTSD* posttraumatic stress disorder, *ICD* international classification of diseases, *DSM* Diagnostic and Statistical Manual of Mental Disorders, *PHQ-9* Patient Health Questionnaire, *AUDIT* Alcohol Use Disorders Identification Test, *DAST* Drug Abuse Screen Test, *MOS SF* Medical Outcomes Study Short Form

**Table 3** TSOS implementation assessments and corresponding RE-AIM framework domains

Assessment	Patient, provider or site assessment	How assessed	N	RE-AIM domain, level
Characteristics of 24 study sites versus all other US sites [35]	Site recruitment	CONSORT	24/224	Adoption, site
Organizational change, climate and culture surveys [95–102]	Trauma center providers	Web-based survey	10*24	Implementation, provider
Weekly recruitment log activity [16, 25, 70]	PTSD interventionist	Recruiting logs	24	Implementation, provider and site
Clinical notes in decision support tool [16]	PTSD interventionist	Decision support tool	24	Implementation, provider
Patient flow through protocol utilizing trauma registry, recruitment data [16, 25, 70]	Patient flow	CONSORT	960	Reach, patient
PTSD and comorbidity, gender and ethnicity groups [16, 25, 70]	Patient outcomes	Telephone interview	960	Effectiveness, patient
EHR, trauma registry, self-report logs [16, 25, 70]	Patient outcomes	Multiple sources	960	Implementation, patient
>6 months follow-up after intervention [16, 25, 70]	Patient 12-month follow-up	Phone	960	Maintenance, patient
Semi-structured key informant interviews [121–125]	PTSD interventionist	Phone	24	Implementation and maintenance, provider and site
National trauma center questionnaire [26, 30]	All US level I centers	Web	224	Maintenance, site

*RE-AIM* reach effectiveness adoption implementation maintenance, *EHR* electronic health record

*Depressive symptoms.* The 9-item Patient Health Questionnaire (PHQ-9) brief depression severity measure will be used to assess depressive symptoms [82]. The PHQ-9 has established reliability and validity in acute and primary care medical patients [16, 25, 83].

*Suicidal ideation.* The PHQ-9, item 9, will be used to assess for suicidal ideation [84].

*Alcohol use problems.* The Alcohol Use Disorder Identification Test (AUDIT), a ten-item screening instrument for the early identification of problem drinkers will be used to assess alcohol use problems before and after the injury hospitalization [85]. The AUDIT's reliability and validity are well established, and the scale has been widely used in acute and primary care medical settings [16, 25, 85–87].

*Limitations in physical function.* The investigation will use the Medical Outcomes Study Short Form (MOS SF) SF-12 at baseline and SF-36 at 3-, 6-, and 12-month follow-up to assess physical, role, and social functional outcomes. The SF-12/36 has established reliability and validity [88], and the measure has been used extensively with traumatically injured populations [89–91].

C. Baseline patient trauma center/emergency department electronic health record (EHR) assessment

EHR data will be collected from each of the 24 sites during the recruitment of study patients. Similarly, trauma registry data will be obtained from each of the 24 sites that will contain EHR derived international classification of diseases (ICD) codes and other clinical data.

*EHR 10 item PTSD risk factor screen.* A previously developed EHR screen will be used to assess admitted injured trauma survivors at risk for the development of PTSD [55]. The screen utilized ten data elements that are both associated with increased risk for PTSD and that are readily available in any robust EHR system. When the ten data elements were used to predict scores on the PTSD Checklist of >35, the EHR screen demonstrated adequate sensitivity (0.71), specificity (0.66), and area under the ROC curve (0.72) [55].

*Injury severity.* Injury severity will be abstracted from the medical record using a conversion software program that transforms recognized ICD codes into the Abbreviated Injury Scale (AIS) and subsequent injury severity scores (ISS) [92].

*Traumatic brain injury (TBI).* Mild, moderate, and severe TBI will be identified and categorized from electronic record abstracted ICD codes indicative of traumatic injury.

*Medical conditions.* Comorbid chronic medical conditions will also be taken from medical record

and trauma registry data and will be derived from ICD diagnostic codes [93, 94]. Chronic medical comorbidity will also be assessed through patient self-report during the follow-up interviews.

D. Provider assessments

*Trauma center organizational assessments* [95–100]. The study will modify previously developed organizational culture and climate assessment scales to evaluate trauma center organizational characteristics related to PTSD and comorbidity service implementation [95, 101, 102].

Organizational implementation scales will assess the extent to which trauma centers were able to adapt to the changes required by PTSD and comorbidity screening and intervention service development [96, 101]. Trauma center provider attrition from the study and turnover will also be examined. Following the procedure established in the study team's previous Disseminating Organizational Screening and Brief Intervention Services (DO-SBIS) pragmatic trial, ten providers from each of the 24 sites will be identified through an organizational mapping procedure to be part of the organizational work unit impacted by screening and intervention service delivery [101, 103]. These ten providers will complete the organizational assessment prior to beginning intervention activities and again in study year 4 after all patient intervention is complete.

*Trauma center provider exposure to critical incidents and job stress* [104, 105]. Previously developed items will be used to assess trauma center provider job-related stress (e.g., call frequency, work volume) [104]. Provider secondary traumatic stress, lifetime trauma, and PTSD symptoms will also be assessed [6, 58, 81, 106, 107].

*Intervention provider standardized patient assessments* [108]. In the study team's prior DO-SBIS pragmatic trial focusing on alcohol screening and intervention, standardized patient fidelity assessments were used to assess fidelity to MI interventions delivered by front-line trauma center providers. Each standardized patient interview was scored using the Motivational Interviewing Treatment Integrity (MITI) coding system. The MITI will again be used to code patient standardized interviews in the current TSOS study.

E. Exploratory health economic evaluation

The cost assessments are intended to contribute to an understanding of the resource implications of the intervention and to American College of Surgeons' and other national policy dialogues of post-injury health service utilization and costs to support subsequent intervention scale-up and spread [109–118]. The investigation will collect detailed information on



the following: (1) the costs of intervention implementation and delivery, (2) post-injury health service utilization costs (e.g., inpatient, skilled nursing facility, emergency room, and outpatient utilization), and (3) the costs of patient medications post-injury. Costs of intervention are likely to be dwarfed by the total costs of post-injury care, which would make it difficult to estimate the incremental costs of intervention precisely, given our sample size. The health care resource utilization and cost analyses constitute an important exploratory aim of the investigation.

#### F. Study team logging procedures

The approach to trial logging simultaneously aimed to satisfy the pragmatic trial requisite for the minimization of time intensive research methods that require extensive adjudication [39] and the implementation science goal of understanding and documentation of trial processes that could yield sustainable maintenance of screening and intervention procedures [27].

Because pragmatic trials tacitly aim to provide health care delivery settings with readily implementable intervention models, logging procedures that differentiate study team activities related to (1) the fielding of the trial, (2) the implementation of evidence-based interventions, (3) costing and economic analyses, and (4) regulatory procedures may be critical for pragmatic trial design and implementation. Previously articulated procedures for the logging of clinical trial and implementation activities were adapted for the current pragmatic trial approach [119, 120]. A pragmatic trial framework that emphasized time efficiency and minimal adjudication of logged activities argued for optimizing parsimony in the logging approach [39]. All study research team site contacts, including email, phone, and in-person site contacts, and all study team consultant (e.g., trauma surgery champion) contact with sites are logged. Both 24 site specific logs and domain specific logs (i.e., trial specific activities, evidence-based intervention implementation, sustainability, and economic considerations) will be maintained. As part of the study's mixed method assessment procedures, the logs and field notes will be reviewed on an approximately monthly basis with the investigation's mixed methods consultant [70, 121–123].

#### G. Semi-structured provider interviews [124, 125]

After the completion of recruitment and intervention activities, semi-structured interviews will be conducted with interventionists from each of the 24 trauma center sites. The interviews will explore barriers and facilitators of implementation of screening, intervention, and quality documentation

procedures for PTSD and comorbidity at trauma center sites. The interviews will also explore the potential sustainability of study procedures.

### Statistical analysis plan

#### Study aims and hypotheses

The primary hypothesis is that the intervention group when compared to the control group will demonstrate significant reductions in PTSD symptoms over the course of the year after injury. Secondary hypotheses are that intervention patients when compared to control patients will demonstrate significant reductions in depressive symptoms and associated suicidal ideation, significant reductions in alcohol use problems, and improved post-injury physical function.

All primary statistical analyses will be conducted using intent-to-treat methods. The primary goal of the statistical analyses is to examine and compare trends over time in the symptoms of PTSD. This analytic approach will be replicated for all secondary outcomes; secondary analyses will examine trends over time for depression, alcohol use, and physical function. The major outcome variables are the continuous and dichotomous assessments of PTSD (PTSD Checklist [81]), depression (PHQ-9 [82]), alcohol use problems (AUDIT [85]), and physical function (MOS SF-36 PCS [88, 126]).

The study team will use mixed effects regression models to test the hypotheses. The investigative group has extensive experience with these analytic approaches in the analyses of longitudinal data after injury. These analytic approaches allow for the modeling of longitudinal data on patients, nested within trauma center sites (see also sample size and power discussion below for a more in-depth explanation of clustering). An important potential advantage of using longitudinal mixed models is the ability to use partial data on those subjects with missing data, and therefore potentially ameliorate selection bias due to drop out. In addition, mixed models naturally structure patient and trauma center heterogeneity specifically allowing for random effects such as individual intercepts and slopes over time. Longitudinal regression models also allow the use of baseline covariates that may be prognostic or reflective of the study design.

Exploratory analyses will assess the impact of the intervention on primary and secondary outcomes for patients with and without pre-injury chronic medical conditions and those with and without TBI. Exploratory analyses will also assess for significant reductions in suicidal ideation, pain, and drug use problems in intervention patients when compared to control patients.

The study team will use a stepped wedge cluster randomized design for the TSOS protocol [40–43] (Fig. 3). Variability in multiple trauma center characteristics can

impact rates of recruitment (e.g., admission volumes, EHR capacity), rates of PTSD (e.g., percentages of patients with violent injury admissions, intensive care unit admission rates), and the ability to follow patients longitudinally (e.g., patient demographic characteristics such as being homeless, clinical characteristics such as substance use problems). The stepped wedge design randomizes level I trauma center sites to sequentially initiate the intervention, thus allowing within site pre- and post-intervention comparisons, as well as between site comparisons. An additional advantage of the stepped wedge design for the protocol is that it would be impractical to roll out the entire intervention at 24 sites simultaneously. Finally, from an implementation science perspective, there is an advantage to having the intervention ongoing at the end of the study at every site, should the intervention demonstrate a significant impact on PTSD and comorbidity (Fig. 1). Given that there is little threat of contamination at each site across intervention and control patients and that the UH3 can accommodate the increased potential length of active recruitment and follow-up, the stepped wedge design appears to be an optimal choice for the TSOS protocol.

#### Sample size and power

A number of issues specific to the design and analyses of cluster randomized trials are addressed by the current power analyses [127–131]. A key consideration for the trial is the nesting of patients within trauma center sites and the ascertainment of associated intraclass correlations (ICC). The study team has extensive experience with prior multisite trauma center observational and pragmatic clinical trial investigations. Sample size estimates were therefore adjusted for the clustering of patients within trauma center sites, using appropriate ICCs derived from the study team's prior multisite investigations (Table 4).

Some attrition is expected in the study sample due to the research context and the population under study (i.e., low income, ethnoculturally diverse, injured trauma survivors). Prior studies by the investigative group have consistently achieved follow-up completion rates >75–80 % at 6–12 months post-injury with this population [16, 24, 25, 132]. Estimates derived from these rates are incorporated into the descriptions of subject flow and power analyses. Table 4 delineates the parameters used to estimate power for the PTSD Checklist, PHQ-9, AUDIT, and MOS SF-PCS. Sample size estimates were derived using the STATA statistical package [133]. With each of the 24 trauma center sites recruiting 40 patients into the study, the study has 80 % power to detect effect sizes of 0.23. These effect sizes are smaller than our previously observed treatment effect for PTSD symptoms of 0.34. In prior investigations, PTSD treatment effects of

**Table 4** Stepped wedge power for TSOS outcomes

Continuous outcomes	PTSD Checklist	PHQ-9	AUDIT	MOS SF-PCS
Cluster size at baseline	40	40	40	40
Cluster size estimation at 12-month (25 % attrition)	30	30	30	30
Total number of clusters	24	24	24	24
Alpha	0.05	0.05	0.05	0.05
Power	0.8	0.8	0.8	0.8
ICC	0.02	0.0259	0.02	0.02
Baseline mean (SD)	50 (15)	14 (6)	10 (5)	50 (10)
Autocorrelation	0.7	0.7	0.7	0.7
Follow-up time points (including baseline)	4	4	4	4
Minimal detectable effect size	0.23	0.23	0.23	0.23

PTSD posttraumatic stress disorder, PTSD Checklist Civilian Version [58], PHQ-9 Patient Health Questionnaire [82], AUDIT Alcohol Use Disorders Identification Test [85], MOS SF PCS Medical Outcomes Study Short Form Physical Components Summary Score [126], ICC intraclass correlation, SD standard deviation

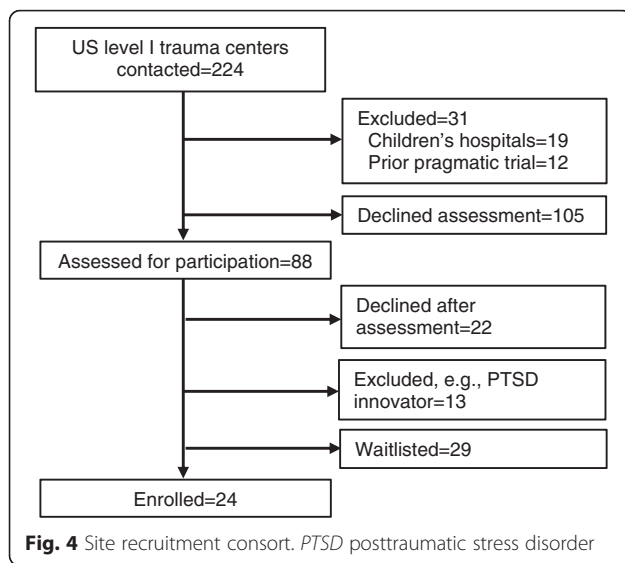
0.34 have been associated with clinically significant and policy relevant functional outcome improvements [25].

#### Mixed method analysis

Mixed methods will be used to integrate the findings from the key informant interviews with pragmatic trial results. The design taxonomy follows a sequential (QUAN → qual) structure in which qualitative data collected from key informants will be used to explain quantitative data results from the pragmatic trial [134, 135]. Qualitative data will therefore be used to expand upon the results of the pragmatic trial in order to understand the implementation and policy processes as experienced by key stakeholders. Second, the sequential QUAN → qual mixed methods design will be used to provide an understanding of pragmatic trial results that require further explanation (e.g., control patients that demonstrate substantial improvement in outcomes, despite not receiving intervention). Results of the mixed method analyses will be presented through a number of modalities that may include key informant narratives, tabular representation of themes with illustrative quotes, and thematic counts [136–139].

#### Trial status

Over the course of the pre-recruitment phase, the TSOS study team has enrolled the 24 trauma center sites that will participate in the trial. The goal of the selection process was to recruit 24 level I trauma centers nationally that would be capable of efficiently implementing the study procedures. The study team sent notification emails and/or contacted by telephone individuals at all US level I trauma centers (Fig. 4). Responding centers were asked questions about current PTSD screening and



intervention practices; the study excluded the less than 10 % of “innovator” sites nationally that were already routinely screening and intervening for PTSD and related comorbidity [26]. Pediatric specialty trauma centers were also excluded from the investigation, as elements of the intervention (e.g., the administration of psychopharmacological agents targeting PTSD) are less well established for patients under the age of 18.

With the exception of pediatric trauma center specialty status, the organizational characteristics of the 24 participating sites does not substantially differ from the characteristics of all US level I trauma centers potentially eligible for the study (Table 5). Broad adoption and site level generalizability is an important aim of the investigation as it targets American College of Surgeons’ policy for PTSD and comorbidity screening and intervention for all trauma centers nationwide.

## Discussion

The current effectiveness-implementation hybrid is innovative in its combination of pragmatic trial and implementation science conceptual frameworks. The effectiveness-implementation trial is a “hybrid type II” design that uses a novel, yet time-tested, American College of Surgeons’ policy mechanism as a targeted implementation strategy [27]. Curran and colleagues note that to enhance the relevance of pragmatic studies, comparative effectiveness trials may require modification in order to have increased policy relevance [27]. Curran and colleagues also critique pragmatic comparative effectiveness studies for exclusively targeting effectiveness outcomes with little attention to the implementation processes relevant to general practice settings; these authors note that in contrast, implementation trials focus on the

**Table 5** Organizational characteristics of TSOS study versus other US level I trauma centers ( $N = 222$ )<sup>a</sup>

Characteristic	TSOS TC $n = 24$ $n$ (%)	Other TCs $n = 198$ $n$ (%)	$P$
American College of Surgeons accredited	17 (70.8)	74 (37.4)	0.01
Region of country			0.40
Midwest	7 (29.2)	64 (32.3)	
South/Southeast	4 (16.7)	30 (15.2)	
Northeast/East	5 (20.8)	63 (31.8)	
West	4 (16.7)	28 (14.1)	
Central	4 (16.7)	13 (6.6)	
Rural status	3 (12.5)	24 (12.1)	1.0
Population served			0.03
Adult	7 (29.2)	92 (46.5)	
Adult and pediatrics	17 (70.8)	82 (41.4)	
Pediatrics	0 (0.0)	23 (11.6)	
Missing	0 (0.0)	1 (0.5)	
Teaching hospital	23 (95.8)	162 (81.8)	0.14
Council of teaching hospitals	22 (91.7)	143 (72.2)	0.04
University affiliation	24 (100.0)	189 (95.5)	0.60
Median (IQR)			
Number of interns/residents	327 (282)	224 (297)	0.11
Number of hospital beds	575 (296)	534 (318)	0.40
Number of inpatient admits	26,971 (16,311)	25,699 (14,978)	0.28

TC trauma center, IQR interquartile range

<sup>a</sup>Two of 224 sites were missing organizational data

uptake and adoption of clinical interventions by providers and systems of care [27].

As part of the study’s emphasis on implementation, an American College of Surgeons’ policy summit is scheduled in the final years of the trial. The aim of the policy summit is to facilitate rapid translation of trial results into national policy. The College oversees the development of national policy mandates and clinical best practice guidelines that inform the integrated operation of US trauma centers and affiliated trauma care systems [28, 29, 140]. The College has successfully linked trauma center funding to verification site visits and other quality indicators [28, 141, 142].

In January of 2005, the College made a landmark policy decision to mandate health services targeting screening and intervention for alcohol-related disorders as a requisite for trauma center accreditation [28]. Prior pragmatic randomized clinical trial investigations from the study team provided evidence supporting the College’s alcohol mandate [22, 30, 143]. In May of 2011, the investigators presented results from effective, NIH funded, PTSD screening and intervention trials at a College policy summit [22–24, 70]. For the first time, the College has included PTSD screening and intervention

as a best practice level recommendation in national guidelines for trauma center care. These new College clinical guidelines set the stage for the current effectiveness-implementation hybrid trial that tests high quality, feasibly implemented, screening and intervention procedures for PTSD and related comorbidity. Simultaneously, as the investigation is being conducted, the study team will be actively developing a policy agenda targeting the use of pragmatic trial results to directly inform the policy discussion in the final years of the grant.

The potential for a policy target sets up a novel staged implementation context whereby the fielding of the trial and the implementation of the evidence-based intervention can yield insight into the sustainable delivery of PTSD screening and intervention procedures for trauma centers nationwide. In this context, previously described Rapid Assessment Procedures that harness clinical ethnographic methods to embed participant observation within front-line implementation teams have great potential utility [70, 121–123]. These methods rely on the study team collection of implementation logs and field notes; these logs and field notes can be productively reviewed on a regular basis with the study mixed method consultant in order to maximally harness field observations. This Rapid Assessment Procedures approach simultaneously satisfies the pragmatic trial requisite for minimization of time intensive research methods that require extensive adjudication and the implementation science goal of understanding and documentation of trial processes that could yield sustainable maintenance of screening and intervention procedures.

In summary, a hybrid effectiveness-implementation spectrum pragmatic trial targeting screening and intervention for PTSD and comorbidity can be readily designed and feasibly implemented across US level I trauma centers. These findings highlight the importance of partnerships with professional societies such as the American College of Surgeons' that can provide regulatory mandates in order to enhance widespread implementation of pragmatic trials results.

#### Abbreviations

CBT: cognitive behavioral therapy; DO-SBIS: disseminating organizational screening and brief intervention services; DSM: diagnostic and statistical manual; EHR: electronic health record; ICC: intraclass correlation; ICD: international classification of diseases; MI: motivational interviewing; PRECIS: pragmatic-explanatory continuum indicator summary; PTSD: posttraumatic stress disorder; RE-AIM: reach effectiveness adoption implementation maintenance; SD: standard deviations; TBI: traumatic brain injury; TSOS: trauma survivors outcomes and support.

#### Competing interests

The authors declare that they have no competing interests

#### Authors' contributions

DFZ, JR, DD, DC, EVE, PH, BC, and GJ conceptualized and designed the study. DFZ, JR, DD, JW, LI, RG, and LW acquired the data. JR and JW analyzed the data. DFZ, JR, DD, DC, LP, EVE, JW, LI, RG, PH, BC, LW, and GJ interpreted the

data. DFZ, JR, DD, DC, LP, EVE, JW, LI, RG, PH, BC, LW, and GJ drafted and critically revised the manuscript. DFZ, JR, DD, DC, LP, EVE, JW, LI, RG, PH, BC, LW, and GJ approved the final manuscript.

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## References

- Bonnie RJ, Fulco CE, Liverman CT, editors. Reducing the burden of injury: advancing prevention and treatment. Washington, DC: National Academy Press; 1999.
- McCaig LF. National hospital ambulatory medical care survey: 1992 emergency department summary. Advance data from vital and health statistics. Hyattsville: National Center for Health Statistics; 1994.
- Rice DP, MacKenzie EJ, Jones AS, Associates. Cost of injury in the United States: a report to congress. San Francisco: Institute for Health and Aging, University of California. Baltimore, Md: Injury Prevention Center, The Johns Hopkins University; 1989.
- Bergen GS, National Center for Health Statistics (U.S.). Injury in the United States: 2007 chartbook. DHHS publication no. 2008-1033, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Hyattsville: National Center for Health Statistics; 2008.
- National Center for Injury Prevention. CDC 2012. In: Office of Statistics and Programming. Atlanta, GA: Center for Disease Control and Prevention; 2012.
- Ramstad SM, Russo J, Zatzick D. Is it an accident? Recurrent traumatic life events in level I trauma center patients compared to the general population. *J Trauma Stress*. 2004;17(6):529-34.
- Bergman K, Maltz S, Fletcher J. Evaluation of moderate traumatic brain injury. *J Trauma Nurs*. 2010;17(2):102-8. doi:10.1097/JTN.0b013e3181ecc452.
- Faul M, Xu L, Wald MM, Coronado VG. Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths 2002-2006. Atlanta, GA: Center for Disease Control and Prevention. National Center for Injury Prevention and Control. 2010.
- United States. 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 Warriors. Washington, DC: President's Commission on Care for America's Returning Wounded Warriors; 2007.
- National Institute of Neurological Disorders and Stroke. Traumatic brain injury: hope through research. Bethesda: National Institute of Health; 2009.
- Krug EG, Sharma GK, Lozano R. The global burden of injuries. *Am J Public Health*. 2000;90(4):523-6.
- World Health Organization. Disease and injury country estimates. 2012. [http://www.who.int/healthinfo/global\\_burden\\_disease/estimates\\_country/en/index.html](http://www.who.int/healthinfo/global_burden_disease/estimates_country/en/index.html). Accessed 5 Jul 2013.
- Norton R, Kobusingye O. Injuries. *N Engl J Med*. 2013;368(18):1723-30. doi:10.1056/NEJMr1109343.
- MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med*. 2006;354(4):366-78. doi:10.1056/NEJMs052049.
- Zatzick D, Rivara FP, Nathens AB, Jurkovich GJ, Wang J, Fan MY, et al. A nationwide US study of post-traumatic stress after hospitalization for physical injury. *Psychol Med*. 2007;37(10):1469-80. doi:10.1017/S0033291707000943.
- Zatzick D, O'Connor SS, Russo J, Wang J, Bush N, Love J, et al. Technology enhanced stepped collaborative care targeting posttraumatic stress disorder and comorbidity after injury: a randomized controlled trial. *J Trauma Stress*. 2015;28(5):391-400. doi:10.1002/jts.22041.
- Parekh AK, Goodman RA, Gordon C, Koh HK. Managing multiple chronic conditions: a strategic framework for improving health outcomes and quality of life. *Public Health Rep*. 2011;126(4):460-71.
- U. S. Department of Health and Human Services. Multiple chronic conditions—a strategic framework: optimum health and quality of life for individuals with multiple chronic conditions. Washington, DC. 2010.
- Wallace RB, Salive ME. The dimensions of multiple chronic conditions: where do we go from here? A commentary on the special collection of preventing chronic disease. *Cent Dis Control Prev*. 2013;10:5.
- Soderstrom CA, Smith GS, Dischinger PC, McDuff DR, Hebel JR, Gorelick DA, et al. Psychoactive substance use disorders among seriously injured trauma center patients. *JAMA*. 1997;277(22):1769-74.
- Zatzick D, Donovan D, Dunn C, Russo J, Wang J, Jurkovich G, et al. Substance use and PTSD in trauma center patients receiving mandated alcohol SBI. *J Subst Abuse Treat*. 2012;43(4):410-7.
- Zatzick D, Roy-Byrne P, Russo J, Rivara F, Driesch R, Wagner A, et al. A randomized effectiveness trial of stepped collaborative care for acutely injured trauma survivors. *Arch Gen Psychiat*. 2004;61(5):498-506. doi:10.1001/archpsyc.61.5.498.
- Zatzick D, Roy-Byrne P, Russo J, Rivara FP, Koike A, Jurkovich GJ, et al. Collaborative interventions for physically injured trauma survivors: a pilot randomized effectiveness trial. *Gen Hosp Psychiat*. 2001;23(3):114-23.
- Zatzick D, Russo J, Lord SP, Varley C, Wang J, Berliner L, et al. Collaborative care intervention targeting violence risk behaviors, substance use, and posttraumatic stress and depressive symptoms in injured adolescents: a randomized clinical trial. *JAMA Pediatr*. 2014;168(6):532-9. doi:10.1001/jamapediatrics.2013.4784.
- Zatzick D, Jurkovich G, Rivara FP, Russo J, Wagner A, Wang J, et al. A randomized stepped care intervention trial targeting posttraumatic stress disorder for surgically hospitalized injury survivors. *Ann Surg*. 2013;257(3):390-9. doi:10.1097/SLA.0b013e31826bc313.
- Love J, Zatzick D. Screening and intervention for comorbid substance disorders, PTSD, depression, and suicide: a trauma center survey. *Psychiatr Serv*. 2014;65(7):918-23. doi:10.1176/appi.ps.201300399.
- Curran GM, Bauer M, Mittman B, Pyne JM, Stetler C. Effectiveness-implementation hybrid designs: combining elements of clinical effectiveness and implementation research to enhance public health impact. *Med Care*. 2012;50(3):217-26. doi:10.1097/MLR.0b013e3182408812.
- American College of Surgeons Committee on Trauma. Resources for optimal care of the injured patient. Washington DC: American College of Surgeons; 2006.
- American College of Surgeons Committee on Trauma. Resources for optimal care of the injured patient. Washington, DC. 2014.
- Terrell F, Zatzick DF, Jurkovich GJ, Rivara FP, Donovan DM, Dunn CW, et al. Nationwide survey of alcohol screening and brief intervention practices at US Level I trauma centers. *J Am Coll Surg*. 2008;207(5):630-8. doi:10.1016/j.jamcollsurg.2008.05.021.
- Johnson KE, Tachibana C, Coronado GD, Dember LM, Glasgow RE, Huang SS, et al. A guide to research partnerships for pragmatic clinical trials. *BMJ*. 2014;349:g6826. doi:10.1136/bmj.g6826.
- Nilsen P. Making sense of implementation theories, models and frameworks. *Implement Sci*. 2015;10:53. doi:10.1186/s13012-015-0242-0.
- Grol RP, Bosch MC, Hulscher ME, Eccles MP, Wensing M. Planning and studying improvement in patient care: the use of theoretical perspectives. *Milbank Q*. 2007;85(1):93-138.
- Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q*. 2004;82(4):581-629.
- Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *Am J Public Health*. 1999;89(9):1322-7. doi:10.2105/AJPH.89.9.1322.
- Rogers EM. Diffusion of innovations. 4th ed. New York: The Free Press; 1995.
- Glasgow RE, Chambers D. Developing robust, sustainable, implementation systems using rigorous, rapid and relevant science. *Clin Transl Sci*. 2012;5(1):48-55. doi:10.1111/j.1752-8062.2011.00383.x.
- Institute of Medicine. Learning healthcare systems concept. Washington D.C. 2008.
- Thorpe KE, Zwarenstein M, Oxman AD, Treweek S, Furlong CD, Altman DG, et al. A pragmatic-explanatory continuum indicator summary (PRECIS): a tool to help trial designers. *J Clin Epidemiol*. 2009;62(5):464-75. doi:10.1016/j.jclinepi.2008.12.011.
- Hussey MA, Hughes JP. Design and analysis of stepped wedge cluster randomized trials. *Contemp Clin Trials*. 2007;28(2):182-91. doi:10.1016/j.cct.2006.05.007.
- Mdege ND, Man MS, Taylor Nee Brown CA, Torgerson DJ. Systematic review of stepped wedge cluster randomized trials shows that design is particularly used to evaluate interventions during routine implementation. *J Clin Epidemiol*. 2011;64(9):936-48. doi:10.1016/j.jclinepi.2010.12.003.
- Woertman W, de Hoop E, Moerbeek M, Zuidema SU, Gerritsen DL, Teerenstra S. Stepped wedge designs could reduce the required sample size in cluster randomized trials. *J Clin Epidemiol*. 2013;66(7):752-8. doi:10.1016/j.jclinepi.2013.01.009.

43. Hughes JP, Granston TS, Heagerty PJ. Current issues in the design and analysis of stepped wedge trials. *Contemp Clin Trials*. 2015;45(Pt A):55–60. doi:10.1016/j.cct.2015.07.006.
44. National Center for Complementary and Alternative Medicine. NIH Health Care Systems Research Collaboratory—Pragmatic Clinical Trials Demonstration Projects (UH2/UH3): National Center for Complementary and Alternative Medicine, 2012 Contract No.: RFA-RM-12-002.
45. Tunis SR, Stryer DB, Clancy CM. Practical clinical trials: increasing the value of clinical research for decision making in clinical and health policy. *JAMA*. 2003;290(12):1624–32.
46. March J, Kraemer HC, Trivedi M, Csernansky J, Davis J, Ketter TA, et al. What have we learned about trial design from NIMH-funded pragmatic trials? *Neuropsychopharmacology*. 2010;35(13):2491–501. doi:10.1038/npp.2010.115.
47. Zwarenstein M, Treweek S, Gagnier JJ, Altman DG, Tunis S, Haynes B, et al. Improving the reporting of pragmatic trials: an extension of the CONSORT statement. *BMJ*. 2008;337:a2390.
48. Federal Coordinating Council for Comparative Effectiveness Research. Report to the President and the Congress. In: US Department of Health and Human Services, editor. Washington, D. C. 2009.
49. Bosch M, McKenzie JE, Mortimer D, Tavender EJ, Francis JJ, Brennan SE, et al. Implementing evidence-based recommended practices for the management of patients with mild traumatic brain injuries in Australian emergency care departments: study protocol for a cluster randomised controlled trial. *Trials*. 2014;15:281. doi:10.1186/1745-6215-15-281.
50. Tavender EJ, Bosch M, Gruen RL, Green SE, Knott J, Francis JJ, et al. Understanding practice: the factors that influence management of mild traumatic brain injury in the emergency department—a qualitative study using the Theoretical Domains Framework. *Implement Sci*. 2014;9(8).
51. Tavender EJ, Bosch M, Gruen RL, Green SE, Michie S, Brennan SE, et al. Developing a targeted, theory-informed implementation intervention using two theoretical frameworks to address health professional and organisational factors: a case study to improve the management of mild traumatic brain injury in the emergency department. *Implement Sci*. 2015; 10(74):22. doi:10.1186/s13012-015-0264-7.
52. Koepsell TD, Zatzick DF, Rivara FP. Estimating the population impact of preventive interventions from randomized trials. *Am J Prev Med*. 2011;40(2): 191–8. doi:10.1016/j.amepre.2010.10.022.
53. Zatzick D, Koepsell T, Rivara FP. Using target population specification, effect size, and reach to estimate and compare the population impact of two PTSD preventive interventions. *Psychiatry*. 2009;72(4):346–59.
54. Richesson RL, Hammond WE, Nahm M, Wixted D, Simon GE, Robinson JG, et al. Electronic health records based phenotyping in next-generation clinical trials: a perspective from the NIH Health Care Systems Collaboratory. *J Am Med Inform Assoc*. 2013. doi:10.1136/amiajnl-2013-001926.
55. Russo J, Katon W, Zatzick D. The development of a population-based automated screening procedure for PTSD in acutely injured hospitalized trauma survivors. *Gen Hosp Psychiatry*. 2013;35(5):485–91. doi:10.1016/j.genhosppsy.2013.04.016.
56. Van Eaton EG, Zatzick D, Gallagher T, Flum D, Tarczy-Hornoch P, Rivara F, et al. A nationwide survey of trauma center information technology and electronic medical record leverage capacity. *J Am Chem Soc*. 2014;219(3): 505–10. doi:10.1016/j.jamcollsurg.2014.02.032.
57. Weathers F, Ford J. Psychometric review of PTSD Checklist (PCL-C, PCL-S, PCL-M, PCL-PR). In: Stamm B, editor. *Measurement of stress, trauma, and adaptation*. Lutherville: Sidran Press; 1996. p. 250–1.
58. Weathers FW, Huska JA, Keane TM. The PTSD checklist-civilian version, The National Center For PTSD. Boston, Ma: Boston VA Medical Center; 1991.
59. Katon W. Health reform, research pave way for collaborative care for mental illness. *JAMA*. 2013;309(23):2425–6. doi:10.1001/jama.2013.6494. Interview by Bridge M Kuehn.
60. Peek CJ. A collaborative care lexicon for asking practice and research development questions. Rockville: Agency for Healthcare Research and Quality; 2011.
61. Dobscha SK, Corson K, Perrin NA, Hanson GC, Leibowitz RQ, Doak MN, et al. Collaborative care for chronic pain in primary care: a cluster randomized trial. *JAMA*. 2009;301(12):1242–52. doi:10.1001/jama.2009.377.
62. Finley EP, Bollinger M, Noel PH, Amuan ME, Copeland LA, Pugh JA, et al. A national cohort study of the association between the polytrauma clinical triad and suicide-related behavior among US Veterans who served in Iraq and Afghanistan. *Am J Public Health*. 2015;105(2):380–7. doi:10.2105/AJPH.2014.301957.
63. Pugh MJ, Finley EP, Copeland LA, Wang CP, Noel PH, Amuan ME, et al. Complex comorbidity clusters in OEF/OIF veterans: the polytrauma clinical triad and beyond. *Med Care*. 2014;52(2):172–81. doi:10.1097/mlr.0000000000000059.
64. Zatzick D, Simon GE, Wagner AW. Developing and implementing randomized effectiveness trials in general medical settings. *Clin Psychol: Sci Pr*. 2006;13:53–68. doi:10.1111/j.1468-2850.2006.00006.x.
65. Rollman BL, Belnap BH, LeMenager MS, Mazumdar S, Houck PR, Counihan PJ, et al. Telephone-delivered collaborative care for treating post-CABG depression: a randomized controlled trial. *JAMA*. 2009;302(19):2095–103. doi:10.1001/jama.2009.1670.
66. Rollman BL, Belnap BH, Mazumdar S, Houck PR, Zhu F, Gardner W, et al. A randomized trial to improve the quality of treatment for panic and generalized anxiety disorders in primary care. *Arch Gen Psychiatry*. 2005; 62(12):1332–41. doi:10.1001/archpsyc.62.12.1332.
67. Bruce ML, Ten Have TR, Reynolds 3rd CF, Katz II, Schulberg HC, Mulsant BH, et al. Reducing suicidal ideation and depressive symptoms in depressed older primary care patients: a randomized controlled trial. *JAMA*. 2004; 291(9):1081–91. doi:10.1001/jama.291.9.1081.
68. Katon W, Von Korff M, Lin E, Walker E, Simon GE, Bush TB, et al. Collaborative management to achieve treatment guidelines: impact on depression in primary care. *JAMA*. 1995;273(13):1026–31.
69. Katon WJ, Lin EH, Von Korff M, Ciechanowski P, Ludman EJ, Young B, et al. Collaborative care for patients with depression and chronic illnesses. *N Engl J Med*. 2010;363(27):2611–20.
70. Zatzick D, Rivara F, Jurkovich G, Russo J, Trusz SG, Wang J, et al. Enhancing the population impact of collaborative care interventions: mixed method development and implementation of stepped care targeting posttraumatic stress disorder and related comorbidities after acute trauma. *Gen Hosp Psychiatry*. 2011;33(2):123–34. doi:10.1016/j.genhosppsy.2011.01.001.
71. Roy-Byrne P, Craske MG, Sullivan G, Rose RD, Edlund MJ, Lang AJ, et al. Delivery of evidence-based treatment for multiple anxiety disorders in primary care: a randomized controlled trial. *JAMA*. 2010;303(19):1921–8.
72. Katon W, Von Korff M, Lin E, Simon G, Walker E, Unutzer J, et al. Stepped collaborative care for primary care patients with persistent depression: a randomized trial. *Arch Gen Psychiatry*. 1999;56(12):1109–15.
73. Katon W, Von Korff M, Lin E, Unutzer J, Simon G, Walker E, et al. Population-based care of depression: effective disease management strategies to decrease prevalence. *Gen Hosp Psychiatry*. 1997;19(3):169–78.
74. Katon W, Rutter C, Ludman EJ, Von Korff M, Lin E, Simon G, et al. A randomized trial of relapse prevention of depression in primary care. *Arch Gen Psychiatry*. 2001;58(3):241–7.
75. Wells KB, Sherbourne C, Schoenbaum M, Duan N, Meredith L, Unutzer J, et al. Impact of disseminating quality improvement programs for depression in managed primary care: a randomized controlled trial. *JAMA*. 2000;283(2):212–20.
76. Unutzer J, Katon W, Callahan CM, Williams Jr JW, Hunkeler E, Harpole L, et al. Collaborative care management of late-life depression in the primary care setting: a randomized controlled trial. *JAMA*. 2002;288(22):2836–45.
77. Katon W, Von Korff M, Lin EH, Simon G, Ludman E, Russo J, et al. The pathways study: a randomized trial of collaborative care in patients with diabetes and depression. *Arch Gen Psychiatry*. 2004;61(10):1042–9.
78. Kroenke K, Theobald D, Wu J, Norton K, Morrison G, Carpenter JF, et al. Effect of telecare management on pain and depression in patients with cancer: a randomized trial. *JAMA*. 2010;304(2):163–71. doi:10.1001/jama.2010.944.
79. Unutzer J, Choi Y, Cook IA, Oishi S. A web-based data management system to improve care for depression in a multicenter clinical trial. *Psychiatr Serv*. 2002;53(6):671–3. doi:10.1176/ps.53.6.671.
80. Proctor E, Silmere H, Raghavan R, Hovmand P, Aarons G, Bunger A, et al. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. *Adm Policy Ment Health*. 2010; Epub ahead of print.
81. Weathers FW, Litz BT, Herman DS, Huska JA, Keane TM. The PTSD checklist: reliability, validity, and diagnostic utility. San Antonio, TX: The 9th Annual Meeting of the International Society for Traumatic Stress Studies; 1994.

82. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med*. 2001;16(9):606–13. doi:10.1046/j.1525-1497.2001.01609606.x.
83. Richardson LP, McCauley E, Grossman DC, McCarty CA, Richards J, Russo JE, et al. Evaluation of the patient health questionnaire-9 item for detecting major depression among adolescents. *Pediatrics*. 2010;126(6):1117–23.
84. O'Connor SS, Dinsio K, Wang J, Russo J, Rivara FP, Love J, et al. Correlates of suicidal ideation in physically injured trauma survivors. *Suicide Life Threat Behav*. 2014. doi:10.1111/sltb.12085.
85. Babor TF, De La Fuente JR, Saunders J, Grant M. The alcohol use disorders identification test: guidelines for use in primary health care. Geneva: World Health Organization; 1989.
86. Reinert DF, Allen JP. The alcohol use disorders identification test: an update of research findings. *Alcohol Clin Exp Res*. 2007;31(2):185–99. doi:ACER29510.1111/j.1530-0277.2006.00295.x.
87. Bradley K, Lapham G, Richards J, Merrill J, Williams E, Lee A, et al. Results of population-based, proactive outreach to non-treatment seeking primary care patients at high risk for AUD in the choice trial. 2014.
88. Ware JE, Snow KK, Kosinski M. SF-36 health survey: manual and interpretation guide. Boston, MA: The Health Institute, New England Medical Center; 1993.
89. Zatzick D, Jurkovich GJ, Gentilello LM, Wisner DH, Rivara FP. Posttraumatic stress, problem drinking, and functioning 1 year after injury. *Arch Surg*. 2002;137(2):200–5.
90. MacKenzie EJ, McCauley ML, Ditunno JF, Forrester-Staz C, Gruen GS, Marion DW, et al. Using the SF-36 for characterizing outcome after multiple trauma involving head injury. *J Trauma*. 2002;52(3):527–34.
91. Michaels AJ, Michaels CE, Moon CH, Smith JS, Zimmerman MA, Taheri PA, et al. Posttraumatic stress disorder after injury: impact on general health outcome and early risk assessment. *J Trauma*. 1999;47(3):460–7.
92. The Johns Hopkins Health Services Research and Development Center. Determining injury severity from hospital discharges: a program to map ICD-9DM diagnoses into AIS, and ISS severity scores. Baltimore, MD. 1989
93. MacKenzie EJ, Morris JA, Edelstein SL. Effect of pre-existing disease on length of hospital stay in trauma patients. *J Trauma*. 1989;29:757–64.
94. Zatzick D, Kang SM, Muller HG, Russo JE, Rivara FP, Katon W, et al. Predicting posttraumatic distress in hospitalized trauma survivors with acute injuries. *Am J Psychiatry*. 2002;159(6):941–6.
95. Hogan SJ, Coote LV. Organizational culture, innovation, and performance: a test of Schein's model. *J Bus Res*. 2014;67(8):1609–21. doi:10.1016/j.jbusres.2013.09.007.
96. Caldwell SD, Herold DM, Fedor DB. Toward an understanding of the relationships among organizational change, individual differences, and changes in person-environment fit: a cross-level study. *J Appl Psychol*. 2004;89:868–82.
97. Zatzick CD, Zatzick DF. The effects of job impact and person-job fit on employee attitudes towards change in trauma centers. San Antonio, TX: Academy of Management Annual Meeting; August 16, 2011.
98. Hom P, Griffeth R. Employee turnover. Reading, MA: Addison-Wesley; 1995.
99. Mobley WH. Employee turnover: causes, consequences, and control. Reading, MA: Addison-Wesley; 1982.
100. Zatzick CD, Elvira MM, Cohen LE. When is more better? The effects of racial composition on voluntary turnover. *Organ Sci*. 2003;14(5):483–96.
101. Zatzick CD, Zatzick DF. The effect of perceived person-job fit on employee attitudes toward change in trauma centers. *Health Care Manage Rev*. 2012;38(2):115–24. doi:10.1097/HMR.0b013e318249aa60.
102. Adams GA, Beehr TA. Turnover and retirement: a comparison of their similarities and differences. *Pers Psychol*. 1998;51(3):643–65.
103. Zatzick D, Donovan DM, Dunn C, Jurkovich GJ, Wang J, Russo J, et al. Disseminating Organizational Screening and Brief Intervention Services (DO-SBIS) for alcohol at trauma centers study design. *Gen Hosp Psychiat*. 2013;35(2):174–80. doi:10.1016/j.genhosppsy.2012.11.012.
104. Bellal J, Pandit V, Hadeed G, Kulvatunyou N, Zangbar B, Tang A, et al. Unveiling posttraumatic stress disorder in trauma surgeons: a national survey. *J Trauma Acute Care Surg*. 2014;77(1):148–54. doi:10.1097/TA.0000000000000271.
105. Bride BE, Robinson MM, Yegidis B, Figley CR. Development and validation of the secondary traumatic stress scale. *Res Social Work Prac*. 2004;14(1):27–35. doi:10.1177/1049731503254106.
106. Kessler R, Sonnega A, Bromet E, Hughes M, Nelson CB. Posttraumatic stress disorder in the National Comorbidity Survey. *Arch Gen Psychiatry*. 1995;52(12):1048–60. doi:10.1001/archpsyc.1995.03950240066012.
107. Kessler R, Berglund P, Demler O, Jin R, Merikangas K, Walters E. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry*. 2005;62(6):593–602.
108. Darnell D, Dunn C, Atkins D, Ingraham L, Zatzick D. A randomized evaluation of motivational interviewing training for mandated implementation of alcohol screening and brief intervention in trauma centers. *J Subst Abuse Treat*. 2015. doi:10.1016/j.jsat.2015.05.010.
109. Services CfMM. Bundled payments for care improvement (BPCI) initiative: general information. <http://innovation.cms.gov/initiatives/bundled-payments/>. Accessed 28 Oct 2013.
110. Vashi AA, Fox JP, Carr BG, D'Onofrio G, Pines JM, Ross JS, et al. Use of hospital-based acute care among patients recently discharged from the hospital. *JAMA*. 2013;309(4):364–71. doi:10.1001/jama.2012.216219.
111. Adams JG. Emergency department overuse: perceptions and solutions. *JAMA*. 2013;309(11):1173–4. doi:10.1001/jama.2013.2476.
112. Burke RE, Coleman EA. Interventions to decrease hospital readmissions keys for cost-effectiveness. *JAMA Intern Med*. 2013;173(8):695–8. doi:10.1001/jamainternmed.2013.171.
113. Shafi S, Barnes S, Nicewander D, Ballard D, Nathens AB, Ingraham AM, et al. Health care reform at trauma centers—mortality, complications, and length of stay. *J Trauma*. 2010;69(6):1367–71. doi:10.1097/TA.0b013e3181fb785d.
114. Shafi S, Ogola G, Fleming N, Rayan N, Kudyakov R, Barnes SA, et al. Insuring the uninsured: potential impact of Health Care Reform Act of 2010 on trauma centers. *J Trauma Acute Care Surg*. 2012;73(5):1303–7. doi:10.1097/TA.0b013e318265d219.
115. Bindman AB, Blum JD, Kronick R. Medicare payment for chronic care delivered in a patient-centered medical home. *JAMA*. 2013. doi:10.1001/jama.2013.276525.
116. Khoury AL, Charles AG, Sheldon GF. The trauma safety-net hospital under the Affordable Care Act: will it survive? *J Trauma Acute Care Surg*. 2013. doi:10.1097/TA.0b013e3182924977.
117. Frankel HL, Butler KL, Cuschieri J, Friese RS, Huynh T, Mohr AM, et al. The role and value of surgical critical care, an essential component of Acute Care Surgery, in the Affordable Care Act: a report from the Critical Care Committee and Board of Managers of the American Association for the Surgery of Trauma. *J Trauma Acute Care Surg*. 2012;73(1):20–6. doi:10.1097/TA.0b013e31825a78d5.
118. Sacks GD, Hill C, Rogers Jr SO. Insurance status and hospital discharge disposition after trauma: inequities in access to postacute care. *J Trauma*. 2011;71(4):1011–5. doi:10.1097/TA.0b013e3182092c27.
119. Saldana L, Chamberlain P, Bradford WD, Campbell M, Landsverk J. The Cost of Implementing New Strategies (COINS): a method for mapping implementation resources using the stages of implementation completion. *Child Youth Serv Rev*. 2014;39:177–82. doi:10.1016/j.childyouth.2013.10.006.
120. Raghavan R. The role of economic evaluation in dissemination and implementation research. In: Brownson RC, Colditz GA, Proctor EK, editors. *Dissemination and implementation research in health: translating science to practice*. New York: Oxford University Press; 2012. p. 94–113.
121. Palinkas LA, Prussing E, Reznik VM, Landsverk JA. The San Diego East County school shootings: a qualitative study of community-level post-traumatic stress. *Prehosp Disaster Med*. 2004;19(1):113–21.
122. Scrimshaw NS. Rapid assessment procedures—qualitative methodologies for planning and evaluation of health related programmes. Boston, Mass: International Nutrition Foundation for Developing Countries (INFDC); 1992.
123. English M, Nzinga J, Mbindyo P, Ayieko P, Irimu G, Mbaabu L. Explaining the effects of a multifaceted intervention to improve inpatient care in rural Kenyan hospitals—interpretation based on retrospective examination of data from participant observation, quantitative and qualitative studies. *Implement Sci*. 2011;6:124. doi:10.1186/1748-5908-6-124.
124. Benner PE. *Interpretive phenomenology*. Thousand Oaks, CA: Sage; 1994.
125. Creswell J. *Qualitative inquiry and research design: choosing among five traditions*. SAGE Publications: Thousand Oaks; 1998.

126. Ware JE, Kosinski M, Keller SD. A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity. *Med Care*. 1996;34(3):220–3.
127. Donner A, Klar N. Design and analysis of cluster randomization trials in health research. London: Arnold Publishers; 2000.
128. Murray DM, Pals SL, Blitstein JL, Alfano CM, Lehman J. Design and analysis of group-randomized trials in cancer: a review of current practices. *J Natl Cancer Inst*. 2008;100(7):483–91. doi:10.1093/jnci/djn066.
129. Murray DM, Varnell SP, Blitstein JL. Design and analysis of group-randomized trials: a review of recent methodological developments. *Am J Public Health*. 2004;94(3):423–32.
130. Murray DM. Design and analysis of group-randomized trials. New York: Oxford University Press; 1998.
131. Raudenbush SW, Liu X. Statistical power and optimal design for multisite randomized trials. *Psychol Methods*. 2000;5(2):199–213.
132. Zatzick D, Donovan DM, Jurkovich G, Gentilello L, Dunn C, Russo J, et al. Disseminating alcohol screening and brief intervention at trauma centers: a policy-relevant cluster randomized effectiveness trial. *Addiction*. 2014;109(5):754–65. doi:10.1111/add.12492.
133. Hemming K, Girling A. A menu-driven facility for power and detectable-difference calculations in stepped-wedge cluster-randomized trials. *Stata J*. 2014;14(2):363–80.
134. Palinkas LA, Aarons GA, Horwitz S, Chamberlain P, Hurlburt M, Landsverk J. Mixed method designs in implementation research. *Adm Policy Ment Health*. 2011;38(1):44–53.
135. Palinkas LA, Horwitz SM, Chamberlain P, Hurlburt MS, Landsverk J. Mixed-methods designs in mental health services research: a review. *Psychiatr Serv*. 2011;62(3):255–63. doi:10.1176/appi.ps.62.3.255.
136. Miles MB, Huberman M. Qualitative data analysis: an expanded sourcebook. 2nd ed. Thousand Oaks: SAGE Publications; 1994.
137. Creswell JW, Plano Clark VL. Designing and conducting mixed methods research. 2nd ed. Los Angeles: SAGE Publications; 2011.
138. Zatzick D, Kang SM, Hinton WL, Kelly RH, Hilty DM, Franz CE, et al. Posttraumatic concerns: a patient-centered approach to outcome assessment after traumatic physical injury. *Med Care*. 2001;39(4):327–39.
139. Zatzick D, Russo J, Rajotte E, Uehara E, Roy-Byrne P, Ghesquiere A, et al. Strengthening the patient-provider relationship in the aftermath of physical trauma through an understanding of the nature and severity of posttraumatic concerns. *Psychiatry*. 2007;70(3):260–73.
140. American College of Surgeons Committee on Trauma. Resources for the optimal care of the injured patient: 1999. Chicago, IL: Committee on Trauma, The American College of Surgeons; 1999.
141. United States Congress. The Patient Protection and Affordable Care Act. 2010.
142. Fixsen DL, Naoom SF, Blase KA, Friedman RM, Wallace F. Implementation research: a synthesis of the literature. Tampa: University of South Florida, Louis de la Parte Florida Mental Health Institute, National Implementation Research Network; 2005.
143. Gentilello LM, Rivara FP, Donovan DM, Jurkovich GJ, Daranciang E, Dunn CW, et al. Alcohol interventions in a trauma center as a means of reducing the risk of injury recurrence. *Ann Surg*. 1999;230(4):473–80.
144. Teasdale G, Jennet B. Assessment of coma and impaired consciousness: a practical scale. *Lancet*. 1974;2(7872):81–4.
145. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiat Res*. 1975;12(3):189–98.
146. Skinner HA. The drug abuse screening test. *Addict Behav*. 1982;7(4):363–71.
147. Krebs EE, Bair MJ, Damush TM, Tu W, Wu J, Kroenke K. Comparative responsiveness of pain outcome measures among primary care patients with musculoskeletal pain. *Med Care*. 2010;48(11):1007–14.
148. Krebs EE, Lorenz KA, Bair MJ, Damush TM, Wu J, Sutherland JM, et al. Development and initial validation of the PEG, a three-item scale assessing pain intensity and interference. *J Gen Intern Med*. 2009;24(6):733–8.
149. Zatzick D, Rivara F, Jurkovich G, Hoge C, Wang J, Fan M, et al. Multi-site investigation of traumatic brain injuries, posttraumatic stress disorder, and self-reported health and cognitive impairments. *Arch Gen Psychiatry*. 2010;67(12):1291–300.
150. Hoge C, McGurk D, Thomas J, Cox A, Engel CC, Castro CA. Mild traumatic brain injury in U.S. soldiers returning from Iraq. *N Engl J Med*. 2008;358(5):453–63.
151. Zatzick D, Jurkovich G, Rivara F, Wang J, Fan MY, Joesch J, et al. A national US study of posttraumatic stress disorder, depression, and work and functional outcomes after injury hospitalization. *Ann Surg*. 2008;248(3):429–37.
152. Boye KS, Matza LS, Feeny DH, Johnston JA, Bowman L, Jordan JB. Challenges to time trade-off utility assessment methods: when should you consider alternative approaches? *Expert Rev Pharmacoecon Outcomes Res*. 2014;14(3):437–50.
153. Badia X, Monserrat S, Roset M, Herdman M. Feasibility, validity and test-retest reliability of scaling methods for health states: the visual analogue scale and the time trade-off. *Qual Life Res*. 1999;8(4):303–10.
154. Wright DR, Wittenberg E, Swan JS, Miksad RA, Prosser LA. Methods for measuring temporary health states for cost-utility analyses. *Pharmacoeconomics*. 2009;27(9):713–23.

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