Following a Firearm Injury: Recidivism and Behavior Change

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A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2019

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Program Authorized to Offer Degree:

Public Health – Epidemiology

University of Washington

Abstract

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Firearm injuries remain an important and understudied public health problem. Besides the high cost of injury care, loss of work, potential need for long term care and emotional trauma for the individual injured, firearm injuries pose unique harm to the larger community as well. Individuals with a history of firearm injury are at substantially higher risk of subsequent rehospitalization for another firearm or assault-related injury, arrest for a firearm-related or violent crime, non-firearm-related nonviolent crime, or firearm-related death in the five years after discharge from the hospital.

A number of hospitals across the country have created violence intervention programs to specifically help patients who sustain violent injuries. There exist only a few studies of the effectiveness of these programs, some of which had small sample sizes and produced mixed findings. We conducted the Helping Individuals with Firearm Injuries (HiFi) to address this gap. HiFi was a randomized controlled trial of an intervention program that combined a hospital-based intervention, structured community outreach program, and multi-agency attention.

Using a Cox proportional hazards model, the Prentice Williams and Peterson multiple failure survival model and G-computation, we calculated the hazard ratios and survival ratios of the risk of arrest and subsequent injury following an incident firearm injury for the intent-to-treat and per-protocol effect estimates, using administrative data linkages to ascertain outcomes and censoring. We did not find an

effect of the intervention assignment on either arrest or subsequent injury, although participation in the study was associated with a decreased risk of arrest. Next, we conducted a fidelity assessment of the HiFi intervention to ensure that our null findings were not due to poor intervention implementation, but also illustrates how future interventions in this population could be tailored to improve patient engagement. Finally, using survey data on firearm-related behaviors, we sought to describe changes in reported firearm-related behaviors among GSW patients following their injury. Our results suggest that patients with a GSW, especially firearm owners, may change their firearm-related behaviors following injury, some by increasing firearm-related safety and others by increasing frequency of behaviors that may place them at increased risk of subsequent injury.

Overall, we found that patients with firearm injuries are potentially open to interventions that support behavior change. However, the CTI model is likely not intensive enough to change the high risk of subsequent arrest and injury in this population. Future studies aimed at reducing arrest and injury should use more intensive approaches.

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ACKNOWLEDGMENTS

This dissertation would not have been possible without the 232 patients who participated in this study, offering their time, thoughts and sharing their experiences of life following a firearm injury. I owe a huge debt of gratitude to the entire HiFi Study Team, especially Ali Rowhani-Rahbar, Frederick Rivara, Lauren Whiteside, Kevin Haggerty, Anthony Floyd, Jin Wang, and Elizabeth Griffin who taught me so much about how to conduct a behavioral intervention in a culturally appropriate way, the complex factors that these patients face and how to use my role as an epidemiologist to best support patients during this vulnerable time. I also owe thanks to the incredible team of Research Assistants who collected data , enrolled patients, taught me so much about the realities of connecting with our patients and how messy primary data collection can be: Alvaro Martinez, Manal Jmaileh, Lina Benson, Cara Currier, Erin Ballsmith, Alice Yan, Tamara Almira, Serena Skidmore and Navya Gunaje. The last two years spent working with all of you have fundamentally changed how I approach research and how I think about supporting vulnerable patients. None of this would have been possible without funding from the City of Seattle, Arnold Ventures and support from the National Center for Advancing Translational Sciences (UL1 TR002319 & TL1 TR002318), the Alcohol & Drug Abuse Small Grant, the Society for Public Health Education Fellowship and the School of Public Health Endowed Fellowship.

Thank you to our partners at the Center for the Advancement of Critical Time Intervention, Sarah Conover and Daniel Herman, who taught me about how evidence-based interventions are developed and changed over time. Thank you to the data managers and stewards who supported my every data request, spent hours with me on the phone answering questions and whose engagement made this work possible especially Keri-Anne Jetzer, Shauna Carlson, Gabriella Johnson, Mike West and Natasha Close.

Thank you to the Harborview Injury Prevention & Research Center staff who have read every early draft, seen every practice presentation, answered oh-so-many questions and provided coffee-breaks for sanity almost every day for the past 5 years. Brianna Mills, Harriet Saxe, Smita Stepanova-Pednekar, Emma Gause, Jin Wang and Qian Qiu, you have all been an integral part of my success as PhD student.

To the Department of Epidemiology staff, especially Angie Buck, Kevin Schuda, Barb McLaughlin, Matt Anderson, DJ Miller, Julie Nevins, John Paulson, and Sixtine Gurrey, thank you! You have supported my idea for a new student lounge, proofread and compiled grants, helped me get into all of my wish list of courses, kept track of funding in ways that saved me money, taken headshots, and literally helped get my son baptized. I don't know what I would do without you all. To the Department of Epidemiology faculty, I owe you so much. Amanda Phipps for making a Departmental lactation room a reality when I was nursing, Noel Weiss for the many hours of music and conversation, Steve Mooney for the many rabbit holes and willingness to talk through all manner of methodological questions, and to Mary Kernic for the hours of code review and one-on-one instruction.

To my committee and faculty mentors, of whom I have so many! Thank you to Ali Rowhani-Rahbar. Frederick Rivara, Marco Carone, Anjum Hajat, Kathleen Kerr, Monica Vavilala, Saman Arbabi, and Megan Moore. You have written me letters of recommendation, provided both mentorship and sponsorship, created opportunities for me and nurtured my ability to conduct research. To Ali Rowhani-Rahbar, my committee chair, I especially owe a debt of gratitude. You trusted me to analyze and present the first results from HiFi, representing both you and the study. You provided support (including taking care of Kieran during meetings) that was crucial, especially after Kieran was born. You made me feel like a colleague and taught me to trust

my epidemiological instinct. You have made me a more careful, more thoughtful researcher. Thank you.

To my fellow Epi Students– I honestly would not have made it through the program, let alone the classes, without you. I owe my success especially to Barbara Harding, Sophie Mayer, Anne Massey, Michelina Montaño, Jamaica Robinson, Tigran Avoundjian and Jerzy Eisenberg-Guyot. Finally, thank you to my friends and family who have stood by me since I was little, through all of the recitals and performances, missed celebrations and late nights spent studying. I owe an especially large debt to my parents, who not only provided me with every opportunity they could and dropped off homemade soup when I was too busy to cook, also took on the bulk of childcare for Kieran in this last year of my PhD. To my son Kieran, who has shown me just how much the human body can accomplish on no sleep. And to my husband Tanner, who has been by my side throughout the whole process, cooking, cleaning, helping raise our son, conducting code reviews and proof-reading papers. None of this would have been possible without him.

INTRODUCTION

Firearm injuries remain an important and understudied public health problem.[1] Besides the high cost of injury care, loss of work, potential need for long term care and emotional trauma for the individual injured, firearm injuries pose unique harm to the larger community as well.[2–6] Children exposed to firearm violence are at higher risk of adverse outcomes including anger, withdrawal, post-traumatic stress and desensitization to violence.[5] Communities with firearm violence are more likely to experience pervasive fear as a result of that violence.[7] Importantly, the risk of a firearm injury is not evenly distributed in the population. Individuals with a history of firearm injury are at substantially higher risk of subsequent rehospitalization for another firearm or assault-related injury, arrest for a firearm-related or violent crime, non-firearm-related nonviolent crime, or firearm-related death in the five years after discharge from the hospital.[8] Firearm injuries are also understudied. Following the passage of the Dickey amendment in 1996, firearm-related research funding dropped and, as a result, firearm injuries and behavior remain severely understudied. Funding for firearm injury related research is only a fraction (1.6%) of the average funding for causes of death with similar mortality burdens.[9]

No studies to date have evaluated the effect of hospital or community-based interventions on reducing subsequent injury exclusively among firearm injury patients. Similarly, no studies have investigated if firearm-related behaviors that place individuals at risk of sustaining future firearm injury (e.g., unsafe firearm storage) change after sustaining a firearm injury.[10–13] Assessing such behaviors can inform future firearm injury prevention efforts in this patient population.[10,11,14]

DISSERTATION OBJECTIVES

This dissertation was nested within a randomized controlled trial of FI patients that began in March 2016, with recruitment ending December 2018 and follow up continuing through June 2019. The

parent study, Helping Individuals with Firearm Injuries (HiFi), is described in detail in Chapter 1. We begin by conducted an evaluation for the first joint hospital- and community-based intervention delivered exclusively to patients with firearm injuries (Chapter 1). Next, we present results of a fidelity assessment conducted of HiFi to ensure high intervention implementation fidelity (Chapter 3). Finally, we discuss changes in firearm-related behavior including ownership, carrying and storage among patients who have been shot (Chapter 2). We end by summarizing the findings of this dissertation and discussing their implications.

CHAPTER 1. RISK OF SUBSEQUENT INJURY FOLLOWING A FIREARM INJURY: A RANDOMIZED CONTROLLED TRIAL

INTRODUCTION

Approximately 250 individuals present to an emergency department in King County, primarily Harborview Medical Center (HMC), for firearm-related injuries each year. Almost two-third of these patients require admission for their injuries. While the number of patients with firearm injuries (FI) who present to HMC is relatively small, these individuals are at substantially higher risk of subsequent rehospitalization for another firearm or assault-related injury, arrest for firearm-related or violent crime, non-firearm-related nonviolent crime, or firearm-related death in the five years after discharge from the hospital.[13] Thus, interventions among this group of individuals to promote their health and well-being and reduce the high risk of recidivism, morbidity, and mortality are critically needed. Such interventions may also lead to lower rates of firearm violence and its consequences in the community.

Currently, Level 1 trauma centers in the country including HMC are mandated by the American College of Surgeons to provide alcohol screening and brief intervention services to trauma patients, including FI victims. A number of hospitals across the country have created violence intervention programs to specifically help patients who sustain violent injuries. In 1996, the American Academy of Pediatrics published a report stating that while it has been routine to treat victims of child abuse, suicide attempts, and sexual assault via multidisciplinary care protocols, no care guidelines exist that address the unique needs of violently injuries adolescents.[15] In 1998, the U.S. Department of Justice's Office for Victims of Crime recommended that hospital-based counseling and prevention programs be developed. In 2009, the National Network of Hospital-based Violence Intervention Programs was formally established (http://nnhvip.org). These programs seek to engage patients in the hospital during the recovery period as a golden

opportunity ("teachable moment") to change their life and reduce retaliation and recidivism. Through working groups, meetings, e-newsletter, and conferences, network members collaborate in research and evaluation, explore opportunities for funding sustainability, develop and share best practices, and identify ways to collectively have an impact on policy. NNHVIP mainly serve individuals 15-25 years of age; however, some programs extend this range from 7 years through middle age.

While the creation of this infrastructure is a step in the right direction, rigorous research on the effectiveness of these intervention programs is needed. There exist only a few studies of the effectiveness of these programs, some of which had small sample sizes and produced mixed findings.[16–33] Specifically, there have been no randomized trials evaluating the effectiveness of joint hospital-based and community-based violence intervention programs specifically offered to FI victims. If research shows that such programs may not be effective, resources can be better spent on other approaches to reduce gun violence and its associated morbidity and mortality.

We conducted the Helping Individuals with Firearm Injuries (HiFi) to address this gap. HiFi was a randomized controlled trial of an intervention program that combined a hospital-based intervention, structured community outreach program, and multi-agency attention. The hospital-based intervention component is derived from motivational interviewing (MI) which is a patient-centered behavioral technique based on the stages of change model and attempts to engage patients in order to find reason to change behavior.[34,35] By empathetically exploring ambivalent feelings about health-related behavior, MI encourages reduction in risky behavior. Brief interventions utilizing principles of MI have been successful at reducing youth violence in large urban populations that sustained after one year.[18,36] Additionally, a behavioral-based intervention including MI among adolescents admitted to HMC with trauma showed a reduction in weapon

carriage during the year after hospitalization.[20] This approach is appealing as its rationale is plausible and potential harms are minimal.[34] The main aim of MI in this study was to motivate the patient to engage with the extended outreach case management provided by our study interventionist.

The community-based extended outreach program used a modified Critical Time Intervention (CTI) approach, which we subsequently refer to as HiFi-CTI. CTI was developed in New York City during the 1980s to support vulnerable people during "critical periods" of transition in their lives and first tested with a randomized controlled trial aimed at reducing recurrent homelessness among men with mental illness.[37] CTI is a time-limited case management practice delivered by a social worker trained in the CTI model. The aim is to increase support in the community during transition periods such as following discharge from institutional settings.[38,39] CTI facilitates community integration and continuity of care by ensuring that a person has enduring ties to their community and support systems during these and other critical periods. It has been widely employed among veterans, people with mental illness, and homeless or incarcerated individuals [40–45], and meets the Coalition for Evidence-based Policy's rigorous "Top Tier" standard for interventions "shown in well-designed and implemented randomized controlled trials, preferably conducted in typical community settings, to produce sizable, sustained benefits to participants and/or society".[39] CTI was, since its inception, thought of as an intervention that could be applied in a wide variety of contexts. The current study is the first to employ an adaption of the CTI model to assist patients with firearm injuries. The adaptation of CTI for HiFi is described in detail in Chapter 3 of this dissertation. A multidisciplinary team served as an ongoing resource for our Support Specialist, a trained Social Worker who delivered the intervention.

To our knowledge, this is the first randomized trial of a multicomponent dual hospital and community-based intervention exclusively focused on individuals with a FI. Findings of this study can directly impact practice and policy through informing the development of evidence-based programs pertaining to firearm violence in the future.

METHODS

PARENT STUDY - HELPING INDIVIDUALS WITH FIREARM INJURIES [HIFI]

The Helping Individuals with Firearm Injuries (HiFi) study is a cluster randomized controlled trial, with randomization by week, that was conducted at Harborview Medical Center (HMC), the Regional Level 1 Trauma Center in Seattle, WA. Patients who had sustained an assault, unintentional or undetermined firearm injury were enrolled following presentation for a FI to HMC. To be eligible, patients must have been 18 years of age or older at the time of the injury, able to provide consent within 4 weeks following hospital discharge, able to understand and speak English, able to provide at least one direct or alternate contact and planning to reside in King, Pierce, Snohomish, Thurston or Yakima counties for at least 6 months following hospital discharge (see**Error! Reference source not found.** for CONSORT diagram). Regular interim analyses were conducted and presented quarterly to a multidisciplinary team of representatives from local community organizations, law enforcement, and public service agencies to provide oversight and external monitoring.

Eligible patients were identified using the HMC electronic medical record new patient lists by Research Assistants, who also conducted enrollment and follow up visits. Enrollment took place at the bedside, at a follow up appointment or in the community. Enrollment began March 15, 2016 and continued through December 31, 2018 with patient follow up continuing through June 31, 2019. Each patient enrolled prior to June 31, 2018 was followed for 12 months following hospital

discharge, while patients enrolled from July 1, 2018 through December 31, 2018 were followed only until June 31, 2019.

The unit of randomization was the calendar week; that is, the study staff assigned patients with a FI to one of the two groups based on the week in which they were shot and treated at HMC. As such, all patients admitted in the same week would be assigned to the same group. A week was defined as one starting on Monday morning at 8:00 for a duration of seven days. We used block randomization with varying block sizes of 2 and 4, randomly generated by the study statistician, to assign each week to one of the two groups during the trial. This randomization scheme ensured that all victims in the same shooting incident received the same study assignment. In addition, this scheme enhanced the feasibility of the study by facilitating the coordination of efforts among the study staff in delivering the intervention. When approached for enrollment, patients knew which arm of the trial they would be joining if they consented to participate.

Once enrolled, patients in our control arm were provided with usual care, including referrals to services that typically occur in the hospital setting. Patients with gunshot wounds (GSWs) seen at HMC receive many services. First, all patients are seen in the Emergency Department (ED) by an attending Emergency Medicine physician and resident physicians on the trauma team working in the ED. Depending on the nature and location of the GSW, these patients are often seen by specialty consulting services such as orthopedic surgery or vascular surgery. If patients have life-threatening injuries, they are seen by the trauma surgery service including an attending trauma surgeon. In addition, all patients who are victims of violence are seen by a member of the Social Work staff during their hospital stay. Currently, Level 1 trauma centers in the country including HMC are mandated by the American College of Surgeons to provide alcohol screening and brief intervention services to trauma patients, including GSW victims. Patients who are admitted and

screened for substance use (e.g., alcohol and drugs) can be seen by the Harborview Addiction Intervention Service which comprises psychologists and chemical dependency counselors. Lastly, patients who present to HMC for GSWs and suicidal intent receive a comprehensive psychiatric evaluation once they are medically stable. However, currently there is no standardized intervention offered to GSW victims. Starting in 2017, we additionally began providing control patients with a pamphlet we created outlining services that intervention patients had found helpful in their FI recovery (Appendix B).

Patients in the intervention arm received hospital- or community-based motivational interviewing, a community-based extended outreach program, and support by a multidisciplinary team of relevant community agencies to help identify relevant recovery resources.

HiFi-CTI Intervention Components: HiFi-CTI included three phases and began with our study Support Specialist developing a trusting relationship with the patient during the pre- HiFi-CTI period through MI and identifying initial recovery goals. The Support Specialist typically worked with 10-15 active patients at a time, with multiple patients in each phase. In Phase 1, the Support Specialist got to know the patient, assessed the patient's needs, and implemented a transition plan intended to link the patient to services and supports in the community. The plan typically included home visits and other meetings with the patient, the patient's caregivers, and community service providers designed to teach crisis-resolution skills, provide support and advice, and mediate any conflicts. The overarching goal was to connect the patient to people and agencies that will assume the primary role of support.

In Phase 2, the Support Specialist monitored and adjusted the systems of support that were developed during Phase 1. This phase involved fewer meetings with the patient, as the Support Specialist encouraged the patient to problem-solve with the help of community resources and

family members and intervened only if the patient was receiving inadequate support or if a crisis occurred. The overarching goal was to monitor and strengthen a patient's support network and skills. Main components of this phase included observing the operation of the patient's support network, mediating conflicts between the patient and caregivers, supporting modification of the network as necessary, and encouraging the patient to take more responsibility for their care.

In Phase 3, the Support Specialist helped the patient develop and implement a plan to achieve long-term goals (e.g., employment, family reunification) and finalized the transfer of responsibilities to caregivers and community providers. The overarching goal was to terminate HiFi-CTI services with support network safely in place. Main components of this phase included stepping back to ensure that supports could function independently, developing and setting in motion a plan for long-term goals and hosting a meeting with the patient and other supporters to mark final transfer of care.

DATA COLLECTION

The primary outcome of interest for the HiFi study was arrest for any crime, reported to either the courts or the Washington State Patrol (WSP). We evaluated any arrest, arrest for a violent crime, and arrest for a non-violent crime separately. Arrest was measured using the administrative databases maintained by the Washington State Administrative Office of the Courts (AOC) and the WSP. A patient was counted as being arrested if there was a record of arrest in either the AOC or WSP. If there was a discrepancy in dates between the same arrest in each dataset, the earlier date was used.

The secondary outcome of interest was subsequent injury requiring medical treatment in an Emergency Department (ED), hospitalization or an injury resulting in death. Incident injuries were categorized as being violent (i.e. assault-related) or non-violent. This was measured by using the Emergency Department Information Exchange (EDIE), the Harborview Medical Center

Electronic Medical Records (EMR), CareEverywhere, Amalga, the Washington State Comprehensive Hospital Abstract Reporting System (CHARS), the Rapid Health Information Network (RHINO), and Vital Statistics. Subsequent injuries were coded for intent, mechanism, and body region. For all patients enrolled in the study, we used EDIE to identify ED visits in the state of Washington since their enrollment in the study. For each visit indicated in EDIE, we conducted chart reviews using EMR, CareEverywhere, and Amalga to ascertain whether or not the visit was injury-related, an incident injury, mechanism used, body area injured and reason for a return visit (if not an incident injury). We next used patient demographics and the EDIE information on time and location of each ED visit to identify patient visits in RHINO and further supplement any remaining ED visits without known chief complaint. We next supplemented the ED data with hospitalization data from CHARS from 2016-2018 to identify incident injury-related hospitalizations. Finally, we included vital statistics to identify patients who died during our study follow up (Appendix C).

To capture covariate data, patients completed follow up surveys with Research Assistants at 1, 3, 6, 9 and 12 months following hospital discharge with a baseline survey conducted as soon as possible after injury. Surveys were completed in person, over the phone or online using RedCap, a HIPAA compliant web-based survey platform, and patients were given a gift card with the completion of each survey ranging from $25-$50 (amount depended on survey length and time since enrollment). At the beginning of the study, patients completed the same long form survey at baseline and at 1, 3, 6, 9, and 12 months following hospital discharge. Starting September 2017, a shorted version of this form was used at the 1, 3, and 9 month time points to reduce RA data collection burden. Patients who received short form surveys still completed the long form survey

at 6 and 12 months following hospital discharge. For details of which standardized assessments were included in the long form and short form surveys, please see Appendix D.

To assess post-traumatic stress disorder (PTSD), we used the PTSD Checklist developed by the United States Department of Veterans Affairs for civilian use with higher scores indicating more PTSD symptoms (scores range from 17-85).[46] We used the 8 question Patient Health Questionnaire (PHQ) to measure depression where a score $\geq$ 10 is considered major depression (scores range from 0-24).[47] To assess perceived social support, we used the Multidimensional Scale of Perceived Social Support total scale which includes questions assessing relationships with significant others, family, and friends where higher scores indicate greater perceived social support (scores range from 1-7).[48] We used the 16 item Happiness Scale from the Community Reinforcement Approach to measure happiness with higher scores indicating greater happiness (scores range from 16-160).[49] General physical and mental health were assessed using the Short Form Health Surveys (SF-12) for physical health and mental health where higher scores indicate higher levels of health (scores range from 0-100 for both physical and mental health).[50] We used the World Health Organization's Alcohol Use Disorders Identification Test (AUDIT) to assess risky alcohol use with scores of 0-7 indicating low-risk, 8-15 indicating risky or hazardous alcohol consumption, 16-19 indicating high-risk and a score of $\geq$ 20 indicating alcohol dependence (scores range from 0-40).[51] Lifetime drug use was assessed using the World Health Organization's Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) modified by the National Institute on Drug Abuse to assess any lifetime drug use by drug type.[52]

We additionally abstracted patient age, sex, race, ethnicity and injury intent (assault or unintentional) from the patient's electronic medical record of the initial hospital encounter for the firearm injury. Injury severity scores (ISS) were obtained from the Harborview Trauma Registry

following comprehensive review of patient charts by trained abstractors; higher scores represent more severe injuries (scores range from 1-75).

We used the Washington State Jail Booking and Reporting System (JBRS) and King County Jail (KCJ) to identify periods of time where patients are incarcerated while CHARS was used to identify hospitalizations. Depending on the analysis conducted, incarceration and hospitalization counted as time not in the community, and as such not at risk of the outcome and that time was censored.

Study staff responsible for collecting outcome and censoring data, conducting linkages and identifying outcome events were temporarily blinded to the patient's intervention arm during this process as the data linking and adjudication processes were completed prior to merging with a data file that contained patient treatment assignment.

The HiFi study was powered on arrest as the primary outcome of interest. A prior study of patients with FI in Washington State and King County indicated that the rate of subsequent arrest following hospital discharge among these individuals is about 15,528 cases per 100,000 person-years.[8] This translates to a one-year cumulative incidence of arrest at about 14% (i.e., $1 - e^{[-15{,}528/100{,}000]}$). Assuming a significance level of 0.05, a power of 80%, an intervention-to-control ratio of 1, 52 clusters (i.e., weeks) per group during the two-year enrollment phase, a sample size of about 2 patients per cluster (for a total of about 200 FI patients during the two-year enrollment phase), and an intraclass correlation coefficient of 0.01, we expected to be able to identify a minimally detectable risk difference of 11 percentage point for the primary outcome of arrest.

ANALYSES

Descriptive statistics were calculated by study arm to describe differences in patient characteristics not addressed by our randomization scheme. Following an Intent-to-Treat approach, we used a Cox proportional hazards model to calculate the hazard ratio of the risk of

arrest comparing the intervention and control arm of the study over the 12-month follow up period, adjusting for the following covariates: age, stable living, enrollment location, income, prior arrest, and ISS, using jail time, hospitalization, moving out of the state as time not at risk, and clustering by randomization week. If a patient was hospitalized, moved out of the state, or incarcerated, patients were excluded from the risk pool, and then allowed to re-enter after they returned to the community. Death was treated as a censoring event.

To look at whether or not treatment assignment reduced risk of not just the first arrest, but all arrests that occur during the follow up time period, we used the Prentice Williams and Peterson multiple failure survival model. We used the same covariates and time at risk for this model as with the Cox proportional hazards model but included all arrests that occurred during the follow up time.

To produce a more interpretable estimand, we next used G-computation to calculate the survival ratio comparing the probability of arrest in the intervention arm to that in the control arm at the 12-month follow up point following the intent-to-treat approach. To do this, we first fit a cox proportional hazards model as described above, including baseline covariates with no missingness (prior arrest, race, Hispanic, stable living, sex, age, and injury intent). We then created two versions of the HiFi study population with baseline covariates, one version where all patients had been assigned to the treatment arm, and one version where all patients had been assigned to the control arm. For each of these two new datasets, we used the fitted Cox proportional hazards model to predict the proportion of patients who survived at 12 months following discharge without an arrest in each dataset using baseline covariates. The survival ratio was calculated by dividing the proportion of intervention patients presumed to have survived without an arrest at the 12-month

mark by the same in the control arm. This process was repeated 5,000 times to calculate bootstrapped confidence intervals.

To account for whether or not a patient engaged with our interventionist during the study, we used the parametric G-formula to estimate the per protocol effect. Using the SAS Macro for the parametric G-formula, we compared the counterfactual proportion of patients with an arrest if all patients had engaged with our interventionist at least 1 time per study phase for a total of 3 study meetings, to the proportion of patients with an arrest if all patients had been assigned to the control arm. This analysis was adjusted for stable living, sex, age, intent, race, ethnicity and prior arrest baseline covariates, and SF-12 physical and mental scores, happiness, stable living, depression, PTSD, perceived social support collected post-randomization at the 1, and 3 month marks.

For subsequent injury, the same analytic process was followed as with arrest, with the exception that we used prior injury as a covariate instead of prior arrest. All of the analyses were conducted setting the end of follow up at 1-year post-discharge. All study procedures were approved by the University of Washington Human Subjects Division (Institutional Review Board), and study participants provided informed consent for all study procedures. Full trial protocol can be accessed at ClinicalTrials.gov using the following identifier: NCT02630225. Analyses were conducted in SAS and R.[53,54]

RESULTS

Of the 855 patients who presented to HMC with a FI during the enrollment period, a total of 232 patients enrolled in the study with 114 patients in the control arm and 118 patients in the intervention arm. Among patients assigned to the intervention arm, 77 (65.2%) received some intervention from the Support Specialist. Patients in the intervention arm were slightly older

(standardized difference [sd] = 0.14), more likely to be white (sd=0.10), be working (sd=0.14), have unstable housing (sd=0.16), be enrolled following admission (sd=0.17), have a lower income (sd=0.22), have a higher ISS (sd=0.21) (Table 1). A total of 86 control patients (75.4%) and 95 intervention patients (80.5%) completed at least one follow-up survey. Table 2 presents the survey completion proportion at each follow-up point among patients eligible for the corresponding survey.

More intervention patients experienced an arrest or subsequent injury during the follow up period compared to patients in the control arm (48 vs 40 arrests by 1 year and 23 vs 14 injuries by 1 year, respectively). The Cox model Hazard Ratios reflect this, producing estimates that are in line with an increased risk of the outcome in the intervention arm compared to the control arm, although none of the estimates are significant (Hazard Ratio [HR] of first arrest = 1.22, 95% Confidence Interval [CI] = 0.83-1.82; HR of first subsequent injury = 1.53, 95% CI = 0.92-2.54). When we accounted for all subsequent arrests and injuries using the Prentice Williams and Peterson multiple failure survival model, we saw a similar pattern as with the Cox model, but the estimates were attenuated towards the null (HR of any arrest = 1.09, 95% CI: 0.82, 1.45; HR of any injury = 1.84, 95% CI: 1.07, 3.15).

The intent-to-treat G-computation analysis to estimate the counterfactual proportion of patients with an outcome of interest comparing treatment assignments begin to approach statistical significance for some of the estimates, but the estimates remain in line with the Hazard Ratios, demonstrating a decreased proportion of patients in the intervention group who "survived" without arrest or subsequent injury at the 12 month follow up point compared to in the control group (Survival Ratio [SR] of any arrest = 0.93, 95% CI: 0.81-1.03; SR of any subsequent injury = 0.88, 95% CI: 0.52-1.02).

Using the per-protocol effect analysis using G-computation, we found that assignment to the intervention and at least 1 contact point with the interventionist during each study phase resulted in a reduced risk of arrest, but was not associated with risk of incident injury (SR for arrest = 0.94, 95% CI: 0.86, 0.99; SR for injury = 1.03, 95% CI: 0.95, 1.08) (Table 3).

DISCUSSION

This study represents the first randomized controlled trial of a hospital- and community-based intervention delivered exclusively to patients with a firearm injury. Although our analysis did not demonstrate a statistically significant effect on either arrest or subsequent injury following assignment to the intervention arm, this study does offer important insight into violence prevention programs.

As we relied on administrative datasets to capture outcome and censoring data, we were not subject to biases resulting from self-reported data and, assuming patients remained in the State of Washington, had complete follow up for all study patients for our main outcomes of interest, even when patients stopped responding to study staff and completing follow up surveys. For arrest data, we combined WSP and AOC data to ensure arrest ascertainment was as complete as possible. As only 8.7% of ED visits result in hospitalization, we combined EDIE, CareEverywhere, RHINO, HMC electronic medical records to create a novel state-wide dataset of ED visits to supplement our CHARS hospitalization records so that we could capture all injuries requiring ED treatment. Individual chart review was conducted where possible to ensure correct identification of incident injuries following study enrollment. This data collection strategy represents a much more through approach for outcome ascertainment than has been documented in other studies of hospital- and community-based violence interventions.

Although many randomized controlled trials use a Cox proportional hazards model for the primary analysis, the Hazard Ratio is not easily interpretable by policy makers or the general public. Our additional analyses allowed us to more comprehensively understand how the HiFi intervention works for our patients. When we use more sophisticated methods, we saw that the intervention assignment was not associated with change in risk of arrest or injury. However, when a patient engaged with the intervention we would expect there to be a reduced risk of arrest, but no association with injury.

LIMITATIONS

Although our use of administrative datasets is a real strength, it is possible that the salient outcome of interest was not captured as we measured subsequent injury requiring ED treatment, and were unable to capture injuries not treated in an ED (e.g. urgent care clinics). Patients in this vulnerable population may avoid medical treatment for all but the most serious injuries, for fear of law enforcement involvement or concerns over health insurance and payment. While we did not observe statistical significance in our analysis, and the sample size is too small to make any definitive comments on the risk of subsequent injury associated with intervention assignment, patients in the intervention arm may have a higher risk of subsequent injury for a number of reasons. Due to encouragement from the Support Specialist, they may have felt more comfortable seeking medical treatment when they received an injury than the control group. This would have resulted in their having higher reported numbers of subsequent injury but reflect a shift in willingness to engage in services. In line with promoting a return to their pre-critical-event life, HiFi-CTI may have also aided patients in their return to their community faster in the intervention group than would have occurred naturally in the control group. If their pre-study community included crime involvement or engagement in activities that placed them at increased

risk for injury, like their index FI, then we would see an increased risk of subsequent risk and arrest associated with the intervention.

More likely, the intervention applied did not contain the level of intensity necessary to see an effect. The HiFi-CTI program was well implemented according to CTI principals (see Chapter 2 for more details). However, HiFi-CTI and CTI are less intensive than other hospital- and community-based violence intervention programs which have been effective at reducing subsequent violence. *CeaseFire* is one such program that has a robust evidence base demonstrating the programs effect on reducing violence. Developed in Chicago, *CeaseFire* partnered with local hospitals and are notified whenever there is a violent injury admission. Community members with similar histories of assault and trauma and trained in crisis intervention and de-escalation meet patients in the hospital to provide MI and prevent retaliatory violence. Community based staff respond to the site where the violence occurred to intervene and prevent ongoing violence from that incident and work with anyone connected to the violent event. Case managers then provide additional support to the victims and coordinate long-term recovery. Case management continues as long as necessary and is quite intense, with staff seeing their clients in person several times a week. Additionally, there are staff who whose work is to identify and mediate ongoing conflicts such as recent arrests, recent prison releases to prevent violence and engagement with community leaders to change social norms around violence acceptability. This program was associated with statistically significant declines in both actual and attempted shootings in communities with the *CeaseFire* program compared to communities without *CeaseFire*.[55]

In addition to offering a more intensive case management program than HiFi-CTI, *CeaseFire* also engages community organizations as active parts of the intervention and treats

the hospital-based component of the intervention as a violence interruption opportunity rather than motivation for engagement in the program. *CeaseFire* also works closely with all persons impacted by the shooting, not just the victim of violence. The additional services provided by CeaseFire and not by HiFi-CTI may be the intervention components that effect change.

Conclusion

Future violence intervention programs should consider more intensive strategies to reduce violence and involvement in crime. While CTI was initially envisioned as a model that could be applied to multiple populations during a critical time, it is possible that the CTI case management program is not intensive enough to interrupt violence in patients with firearm injuries.

TABLES AND FIGURES

TABLE 1: CHARACTERISTICS FOR HIFI PATIENTS

Characteristic	Total (n=232)	Control (n=114)	Intervention (n=118)
Age in years, mean (IQR)	29.8(11.5)	29.0(11.0)	30.5(13.0)
Male, no. (%)	199(85.8)	99(86.8)	100(84.8)
Race, no. (%)			
White	102(44.0)	47(41.2)	55(46.6)
Black	101(43.5)	52(45.6)	49(41.5)
Asian	10(4.3)	6(5.3)	4(3.4)
Hawaiian/Pacific Islander	9(3.9)	6(5.3)	3(2.5)
American Indian	10(4.3)	3(2.6)	7(5.9)
Hispanic, no. (%)	28(12.1)	14(12.3)	14(11.9)
Employment, no. (%)			
Working	124(58.5)	56(54.9)	68(61.8)
Laid off	41(19.3)	23(22.5)	18(16.4)
Student	18(8.5)	10(9.8)	8(7.3)
Homemaker	4(1.9)	4(3.9)	0(0.0)
Retired	3(1.4)	2(2.0)	1(0.9)
Other	22(10.4)	7(6.9)	15(13.6)
Current living situation, no. (%)			
Stable	157(70.1)	82(73.9)	75(66.4)
Transitional	35(15.7)	17(15.5)	18(15.9)
Unstable	32(14.3)	12(10.9)	20(17.7)
Injury intent, no. (%)			
Assault	169(80.1)	83(79.8)	86(80.4)
Unintentional	41(19.4)	20(18.9)	21(19.4)
Shot by law enforce	1(0.5)	1(0.9)	0(0.0)
Enrollment location, no. (%)			
ED	26(11.6)	16(14.6)	10(8.7)
Inpatient	126(56.0)	57(51.8)	69(60.0)
Clinic	70(31.1)	34(30.9)	36(31.3)
NA	3(1.3)	3(2.7)	0(0.0)
Income, no (%)			
<25K	76(48.1)	29(42.0)	47(52.8)
25-50K	43(27.2)	21(30.4)	22(24.7)
50-100K	25(15.8)	11(15.9)	14(15.7)
>100K	14(8.9)	8(11.6)	6(6.7)
Length of stay in hours, mean (IQR)	133.8(151.2)	132.3(163.9)	135.3(141.6)
ISS, mean (IQR)	10.1(9.0)	9.2(10.5)	11.0(10.0)
Arrested before injury, no. (%)	169(72.8)	83(72.8)	86(72.9)
PHQ total score, mean (IQR)	6.2(9.0)	5.4(7.0)	7.0(11.0)
PCL-C total score, mean (IQR)	34.0(24.0)	32.0(22.0)	36.0(28.0)
SF-12 physical score, mean (IQR)	50.5(12.2)	49.7(13.3)	51.2(10.6)
SF-12 mental score, mean (IQR)	48.8(19.7)	48.9(19.1)	48.6(18.4)
AUDIT-C total score, mean (IQR)	3.0(5.0)	3.0(3.0)	2.9(5.0)
IPAS IA mean score, mean (IQR)	1.8(1.9)	1.7(2.6)	1.9(1.6)
IPAS IA positive %, mean (IQR)	18.8(25.0)	19.4(25.0)	18.3(25.0)

IPAS PM mean score, mean (IQR)	1.5(1.9)	1.5(2.3)	1.5(1.6)
IPAS PM positive %, mean (IQR)	11.5(16.7)	12.6(16.7)	10.5(16.7)
MSPSS total scale, mean (IQR)	5.2(1.4)	5.3(1.7)	5.2(1.2)
MSPSS significant other scale, mean (IQR)	5.3(1.8)	5.4(2.0)	5.2(2.0)
MSPSS family scale, mean (IQR)	5.4(1.5)	5.4(1.8)	5.4(1.5)
MSPSS friend scale, mean (IQR)	4.9(2.0)	5.0(1.9)	4.9(2.0)
HS total score, mean (IQR)	83.2(38.0)	85.3(35.5)	81.3(38.0)
Lifetime drug use based on ASSIST			
Cannabis	189(85.1)	95(87.2)	94(83.2)
Cocaine	94(42.3)	41(37.6)	53(46.9)
Prescription stimulants	48(21.7)	23(21.3)	25(22.1)
Methamphetamine	49(22.2)	20(18.5)	29(25.7)
Inhalants	9(4.2)	5(4.8)	4(3.6)
Sedatives or sleeping pills	50(22.9)	24(22.2)	26(23.6)
Hallucinogens	66(29.7)	31(28.4)	35(31.0)
Street opioids	25(11.3)	10(9.3)	15(13.3)
Prescription opioids	86(38.7)	42(38.5)	44(38.9)
Other	3(1.5)	1(1.0)	2(2.0)

Abbreviations: IQR: Inter-Quartile Range; PHQ-8: Patient Health Questionnaire (depression); PCL-C : PTSD Checklist Civilian Version (post-traumatic stress symptoms); SF: Short Form Health Survey (health-related quality of life); AUDIT: The Alcohol Use Identification Test (alcohol use); IPAS: Impulsive-Premeditated Aggression Scale (aggression); IA: Impulsive Aggression; PM: Premeditated Aggression; MPSS: Multidimensional Scale of Perceived Social Support (social support); HS: Happiness scale (happiness); ASSIST: Alcohol, Smoking and Substance Involvement Screening Test (drug use). **Note:** Stable housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was their address. Transitional housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was not their address. Unstable housing includes individuals who indicated that they were couch surfing, homeless, or in a shelter. **Missing subject**: Current living (n=8), Employment (n=20), Injury intent (n=21), Enrollment location(n=7), Income(n=74), ISS (n=3), SF12 (n=14), IPAS (n=11), PS (n=11), SAL (n=11), AUDIT (n=9), PCLC (n=8), PHQ (n=7), ASSIST (n=10)

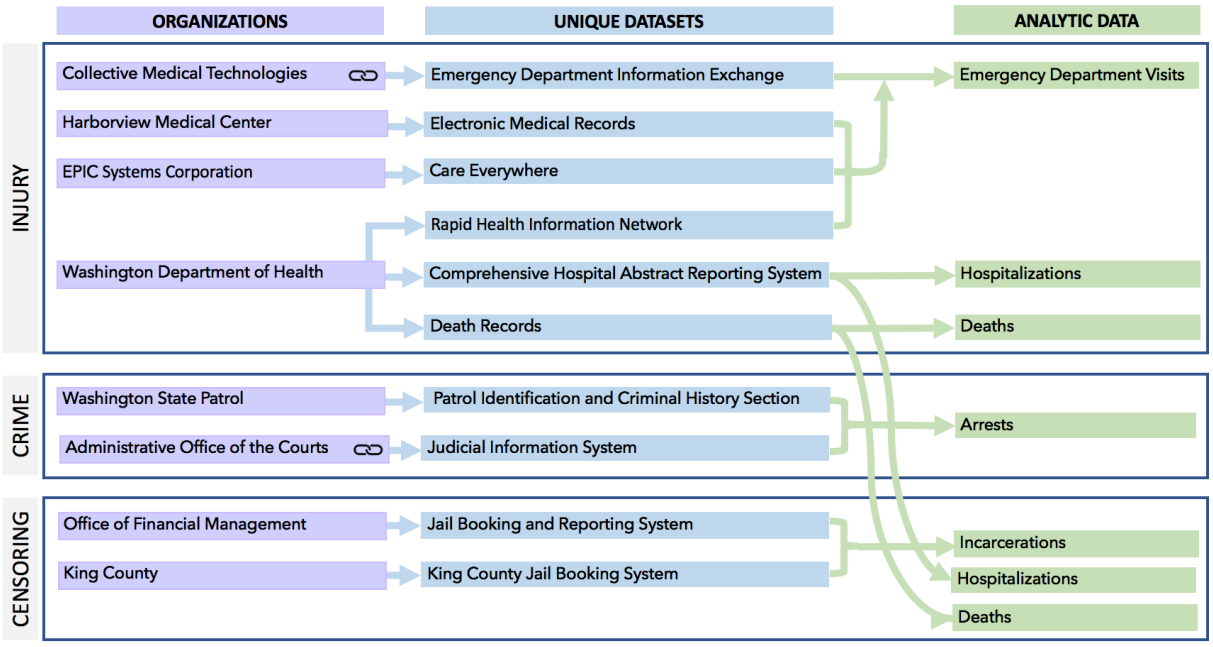
TABLE 2: PROPORTION OF COMPLETED SURVEY AT EACH TIME POINT

Follow-up Month	Control (n=114), %	Intervention (n=118), %	Total (n=232), %
1	58.8 (67/114)	68.6 (81/118)	63.8 (148/232)
3	57.0 (65/114)	63.5 (75/118)	60.3 (140/232)
6	57.9 (66/114)	54.2 (64/118)	56.0 (130/232)
9	50.9 (56/110)	56.0 (65/116)	53.6 (121/226)
12	62.5 (65/104)	58.9 (60/102)	60.6 (125/206)

TABLE 3: RISK OF SUBSEQUENT ARREST AND INJURY IN 12 MONTHS FOLLOWING HOSPITAL DISCHARGE FOR INITIAL FIREARM INJURY

	Analysis	Parameter	Arrest		Injury
Intent-to-treat	Cox model[a]	Hazard Ratio (95% CI)	1.37 (0.89, 2.12)		2.06 (1.06, 4.00)
	Multiple failure model[a]	Hazard Ratio (95% CI)	1.09 (0.82, 1.45)		1.84 (1.07, 3.15)
	G-computation[a]	Proportion with outcome % (95% CI)	C: 19.69 (5.69, 46.73)		C: 20.34 (5.83, 62.34)
			I: 25.24 (8.14, 52.17)		I: 30.32 (9.98, 77.42)
		Relative Risk (95% CI)	1.08 (0.97, 1.23)		1.14 (0.98, 1.92)
Per-protocol effect	G-computation[b]	Proportion with outcome % (95% CI)	C: 35.65 (28.15, 47.44)		C: 14.54 (9.39, 27.16)
			I: 33.40 (26.00, 44.16)		I: 14.91 (10.03, 27.83)
		Relative Risk (95% CI)	0.94 (0.86, 0.99)		1.03 (0.95, 1.08)

FIGURE 1: ILLUSTRATION OF LINKING PROCESSES FOR HIFI DATA SOURCES



Note: 🔗 Indicates that linking occurred at the agency level. All other linking was conducted by our study team.

CHAPTER 2. FIDELITY ASSESSMENT OF A SOCIAL WORK-LED CRITICAL TIME INTERVENTION AMONG PATIENTS WITH FIREARM INJURIES

INTRODUCTION

Implementation fidelity refers to how closely an intervention's real-world implementation aligns with the intended implementation. It is a key component of translating an evidence-based program into practice, as an intervention implemented without fidelity will likely be missing core components of the intervention [65]. Implementation fidelity can be measured in many different ways and a large body of work exists discussing the importance of assessment as well as strategies and conceptual frameworks for assessing implementation fidelity.[66–68]

Importantly, a fidelity assessment offers opportunities to improve program implementation or program delivery based on findings from the assessment during an ongoing trial. It also can identify individual-level challenges with intervention delivery such that investigators and practitioners can proactively prepare for future program intervention delivery in the same population. When there are mixed findings from multiple studies evaluating similar programs in similar populations, fidelity assessments can provide insight into whether conflicting findings were driven by variability in program implementation. However, despite their value, relatively few studies of social work interventions include formal fidelity assessments to improve intervention delivery, or report fidelity measures.[69,70] This paper describes a fidelity assessment of a randomized controlled trial of the social work-led Helping Individuals with Firearm Injuries-Critical Time Intervention (HiFi-CTI) among patients with a firearm injury.

Several established or emerging hospital-based and/or community-based programs have been developed to provide support to patients with a violent injury.[71] However, none of these programs have been studied exclusively among patients with firearm injuries and there is a dearth of literature examining the effectiveness of these programs. The studies that do exist offer mixed

findings and relatively small sample sizes.[16,17,22,27] The mixed findings of these studies may be due, in part, to their program implementation. Our knowledge of how the implementation fidelity may have impacted their findings is limited as implementation data was not reported in a standardized way.

We conducted a fidelity assessment to 1) measure how closely HiFi-CTI followed CTI principles, 2) identify individual-level challenges with HiFi-CTI delivery to offer insight into development of future community-based interventions among patients with firearm injuries, and 3) present fidelity assessment results that can be used to contextualize forthcoming findings on the intervention effect from the parent study and facilitate comparisons with other community-based interventions among similar patient populations. We additionally describe changes made to our program both during and following the assessment to improve intervention delivery among our patient population. This effort will help support future development and refinement of social work-led intervention programs among patients with firearm injuries.

METHODS

Fidelity Assessment Adaptation Process: We partnered with experts from the Center for the Advancement of Critical Time Intervention (CACTI) to conduct the formal fidelity assessment of the intervention. We worked with CACTI to adapt the CTI Fidelity Scale which they have employed previously to evaluate how closely CTI implementations follow CTI principles [72,73]. The original CTI Fidelity Scale includes individual fidelity items to evaluate client-based, worker-based and team-based domains with each individual fidelity item measuring one or two of the basic principles of CTI (Table 4).

The adaptation began with an in-person training on the core CTI principles and existing fidelity assessment tools delivered at CACTI for the fidelity assessment team leader. The fidelity

assessment team then reviewed each individual fidelity criterion to identify elements that needed revision in order to reflect HiFi-CTI, our adapted version of CTI. Following this initial review, we met with the HiFi study team to continue the review, including identifying which of our data elements should be used to evaluate each of the fidelity assessment items as our HiFi-CTI data collection tools differed from CTI data collection tools. Over the course of four months we iteratively refined the HiFi-CTI fidelity assessment in collaboration with our CACTI partners prior to the start of the fidelity assessment.

The adaptation reflected the differences in intervention timeframe, geographic area, and number of Support Specialists between CTI and HiFi-CTI. HiFi-CTI was 6 months long, whereas the initial CTI program was 9 months long. Thus, the number of meetings per time period criteria was reduced to reflect the shorter timeline for HiFi-CTI. Additionally, HiFi was conducted over a 5 county wide geographic area, compared to the typical hyper-local delivery of CTI. As a result, the number of community-based, in-person meetings with the patients required per phase were modified to reflect the HiFi-CTI reliance on alternative forms of communication for intervention delivery.

Finally, the HiFi-CTI program had only one Support Specialist, instead of the multiple support specialists in many other CTI programs, so we modified the fidelity assessment tools to reflect a single Support Specialist. As a result, the *Weekly Team Supervision* fidelity item initially included a criterion outlining Support Specialist attendance to the weekly team meetings when clients were discussed. However, in HiFi, our Support Specialist was, by definition, present for all cases discussed (as they did all case presentations), so we removed that criterion from the HiFi-Fidelity assessment. Similarly, the Team-Based fidelity domain item focused on quality of fieldwork coordination initially included criteria for regular communication between support

specialists while in the field was removed. The final adapted fidelity assessment items for HiFi-CTI are presented in Figure 1.

Fidelity Assessment Process: To ensure that our fidelity assessment would be less subject to random variation in HiFi-CTI program implementation fidelity over time, we defined our fidelity assessment period from 12/1/2017-6/1/2018 and reviewed 6-months of support specialist notes and documentation, using the CACTI recommended sampling and scoring strategy for fidelity assessments. As the fidelity assessment focused on the implementation of HiFi-CTI, we restricted our study to patients in the intervention arm of our parent trial who were eligible for HiFi-CTI. For each of the fidelity assessment items, we followed the sampling strategy for that specific assessment item and reviewed the appropriate documentation including the support specialist's encounter documentation, progress notes, phase plans, phase-date forms, and closing notes from the fidelity assessment period. Encounter documentation included date of contact, phase of patient at the time of the encounter, and location of contact. Progress notes for each encounter included a description of meeting including a summary of the contact, any new goals set, social support or service providers who attended, and plans for next steps in achieving the patient's set goals. Phase plans include the patient stated goals for the upcoming CTI phase. The phase-date form indicated the patient's current phase, Support Specialist's impression of pattern of progress, level of interest and how useful the patient found CTI for each phase separately. Closing notes included a summary of the patient's overall progress through CTI, description of their engagement with the Support Specialist and specific goals met through CTI.

We conducted a focus group with the lead investigators of the study who supervised the support specialist and an interview with the Support Specialist as well. We additionally observed a weekly team supervision meeting. Using the formal fidelity assessment worksheets that had been

adapted in consultation with Sarah Conover, a developer of the CTI Fidelity Scale, we recorded the data and calculated item-specific scores and the overall HiFi-CTI program fidelity score (Figure 1). Following the fidelity assessment, we presented the findings to the HiFi-CTI study team along with recommendations for improving specific fidelity assessment item scores.

Fidelity Assessment Measures: For each individual item in the fidelity assessment, we used the pre-specified worksheets developed by CACTI to assess how closely that specific item aligned with initial CTI goals and practices, with separate worksheets for each fidelity item. For each item worksheet, relevant data were abstracted from chart notes, data on frequency and type of contacts with our Support Specialist as well as from interviews and focus groups (see Figure 2 for data source for each item). Abstracted data were compared to item-specific CACTI set goals and benchmarks.

Fidelity Assessment Scoring: For each item, a score was calculated by dividing the total number of criteria met by the total number of criteria possible. Using the *Intake Assessment and Early Engagement of Client* fidelity item in the Client Based Domain as an example, we used the dates of the fidelity assessment to identify 5 patients who completed Pre-CTI in the time-frame of interest using the CACTI sampling strategy for that item. The number of patients sampled for each HiFi-CTI fidelity assessment item was the same as in the CTI fidelity assessment. We measured two items for each of the 5 sampled patients, 1) if there was $\geq$ 1 meeting with the Support Specialist per month during the Pre-CTI phase, and 2) if the intake assessment was dated during the Pre-CTI phase. The total number of points contributed by each client (max 2) was added for all 5 patients, and then divided by 10 (the total number of possible points for this item) to get the percentage of criteria that were met for this fidelity item (see Figure 2 for all fidelity items).

The overall program fidelity score is calculated by adding fidelity item scores for each item and dividing by the total number of rated items. While each fidelity assessment item is calculated using aggregate patient data, there is no patient-level fidelity score, only item specific and overall program fidelity scores.

Assessing Patient Characteristics Associated with Fidelity: Unlike some interventions, HiFi-CTI allows patients to determine their level of engagement with the Support Specialist. As the fidelity assessment includes measures of patient engagement, enrolling many patients who elect to not participate in HiFi-CTI will result in a reduced fidelity assessment score. As the fidelity assessment did not include any patient-level measures, we additionally created a measure for patient intervention "dose" to allow a more granular examination of patient characteristics associated with participation in HiFi-CTI. We were unable to identify standards for defining intervention dose for CTI programs and related interventions in a literature review. Thus, to reflect the wide variety of patient engagement in our study, we defined a continuous intervention dose where each in-person contact or phone call during the 6-month intervention period following pre-HiFi-CTI was counted as a contact with our Support Specialist and increased the patient intervention dose by 1, with no upper limit. Our analysis of intervention dose was restricted to intervention patients who had completed their 6 months of CTI as their dose was liable to change up until the end of Phase 3.

Intervention patients who did not meet with or speak with our Support Specialist had an intervention dose of 0. Text-messaging, emailing and social media messaging did not contribute to increasing the intervention dose, as these methods of communication do not easily facilitate the motivational interviewing and rich discussion that characterize CTI. Although these methods of communication were not included in the dose calculation, they did facilitate communication that led to contacts captured in our dose measure.

Following development of this dose measure, we used the distribution of dose to empirically categorize patients into three groups to facilitate identification of patient characteristics associated with HiFi-CTI engagement. The three groups were: intervention patients with no dose (dose = 0), intervention patients with a low dose ($1 \geq$ dose ≤ 6) and intervention patients with a high dose (dose ≥ 7). Patients were grouped into one of these three groups based on their intervention dose at the end of the 6-month period.

We tested for differences between intervention dose groups using the Fisher's exact or one-way ANOVA tests, as appropriate, for each individual and injury characteristic including injury severity score and injury intent. Patient demographic and injury data were collected at study enrollment using a detailed survey and chart abstraction. Study procedures were approved by the University of Washington's Human Subjects Division (Institutional Review Board), and study participants provided informed consent for all study procedures. Analyses were conducted in Stata 14.[60]

RESULTS

Fidelity Assessment: Using the adaptation of the CTI Fidelity Scale and rating system, the overall implementation of the HiFi-CTI program was found to meet 70% of the HiFi-CTI fidelity items, corresponding to a "well implemented" program (Score of 1 = Not implemented, 2 = Poorly implemented, 3 = Fairly Implemented, 4 = Well Implemented, 5 = Ideally Implemented) (Figure 1). We observed some variability in the average scores for each fidelity assessment domain. Client-based fidelity items had an average score of 3 (i.e. fairly implemented), worker-based fidelity items had an average score of 3, and team-based fidelity items had an average score of 5 (i.e. ideally implemented) (Figure 2).

Intervention Dose: There were 90 intervention patients who had completed HiFi-CTI at the time of the fidelity assessment and were included in this analysis. On average, patients met with our study interventionist for HiFi-CTI intervention delivery 5 times during the 6-month intervention period. Low dose patients had a median of 3 meetings during follow up (Interquartile range [IQR]: 2-5), and high dose patients had a median of 14 meetings during follow up (IQR: 8-17). There was no significant difference between intervention dose groups with respect to age, race, employment, stable housing, injury intent, household income or injury severity score. There was a greater proportion of males in the no intervention dose and low intervention dose groups than in the high intervention dose group (100%, 86% and 73%, respectively; $p < 0.01$). Similarly, a greater proportion of no intervention dose and low intervention dose patients reported an arrest in the year prior to study enrollment compared to high intervention dose patients (84%, 72% and 53%, respectively, $p = 0.03$) (Table 5).

Refinement of Intervention Delivery: Not reflected in our fidelity process scores are the changes made to HiFi-CTI program implementation between the fidelity assessment training and when the fidelity assessment was conducted. During the fidelity assessment training, we realized that the weekly team supervision measure was likely not being met and it was not tracked formally. Initially, our Support Specialist would select the patients thought to need discussion among the study team members. These clients were often selected when the Support Specialist needed help thinking through strategies or services to address specific challenges, if their case was particularly complex and the study team had requested frequent updates or if there was a major change in their case that changed the Support Specialist's approach. While this allowed greater focus on patients in crisis, it resulted in infrequent discussion of other patients. Following the

fidelity assessment training, we began tracking which patients were discussed at each weekly meeting to calculate the proportion of patients discussed per week and per month.

We additionally restructured our weekly meetings so that the Support Specialist had more dedicated time allotted to discuss intervention patients and made it our goal to discuss, however briefly, every intervention patient each month. In November 2017, the first month during which we tracked the proportion of patients discussed per month, we reviewed 69% of patients. In December 2017, we reviewed 86%. By January 2018, we were reviewing 100% of patients every month. Our score of 5 for the weekly team supervision fidelity assessment score is reflective of the integration of these changes. These changes allowed both more opportunity for consistent oversight and increased opportunities to discuss patients. Some patients who were not in crisis and would not initially have been brought up regularly at the team meetings did have complex needs that benefited from group discussion.

DISCUSSION

Overall, the HiFi-CTI program was well implemented according to the principles and core components of the CTI model. Importantly, the process of conducting the fidelity assessment increased our program implementation fidelity and changed practice. We increased the frequency of case discussions of each patient to at least once a month and provided substantially more time in our weekly meetings to the Support Specialist. The assessment process re-focused our attention on intervention oversight and monitoring, providing a level of scrutiny over intervention fidelity that was typical at the start of our study but had lapsed over time. This increased attention likely influenced implementation in other ways not captured in this study, potentially by increasing contact attempts, or improved charting during the fidelity assessment period. In addition, our

selection of the fidelity assessment period may have influenced our results, as there is often natural variation in intervention delivery over time. Future studies could implement regular fidelity assessments to maintain high intervention fidelity and ensure fidelity assessment findings are not reflective of temporal trends.

The assessment process also identified individual patient level factors that influenced overall program implementation fidelity, primarily patient desire to connect with our Support Specialist and engage with other community supports and service providers. This would directly impact five of the seven client-based fidelity assessment items (Figure 2). Our development of the intervention dose measure was a first attempt to identify patients who might require more proactive engagement during the pre-HiFi-CTI phase. This measure could be refined and employed in future CTI adaptions with similar patient populations to improve patient engagement with the intervention.

Unlike prior adaptations of CTI, our patients demonstrated more systems avoidance than in other studies, including changing their phone numbers frequently, frequently moving, not providing home address or forwarding information. This systems avoidance may be due to fear, especially amongst patients with an assault-related firearm injury. Assault patients have voiced concern over their shooter attacking them again and have discussed employing multiple strategies to ensure their safety including changing their phone number, moving frequently and not disclosing their location to family or friends. In addition, a greater proportion of patients who reported an arrest in the past year had no intervention dose compared to patients with a high intervention dose. Recent engagement in the criminal justice system may have also led patients to eschew communication with our Support Specialist and study team for fear of reporting illegal behavior to law enforcement. These behaviors increase the difficulty of meeting regularly with the

Support Specialist and increase likelihood of dropouts. Future violence intervention programs, especially programs like HiFi-CTI that require many in-person contacts among patients with firearm injuries, should proactively consider how to structure their patient contacts to counteract systems avoidance. One strategy could include adopting a "neighborhood storefront" approach to the staff office, as was done in the initial CTI trial, where the office welcomes patients to drop in, have a snack and connect with a CTI Support Specialist, even without an appointment [74]. Having a physical space where patients can come to reliably connect with study staff and receive services would provide a good alternative communication strategy for patients who do not feel safe leaving contact phone numbers or addresses. This was attempted for HiFi, but the space available was a conference room in the hospital, not an easily accessible space in the community. It was never utilized by patients.

While conducting the fidelity assessment resulted in increasing weekly team supervision and patient case discussion, the goals and components of the HiFi-CTI intervention remain unchanged. Most importantly, we do not believe that those changes impacted our ability to evaluate the HiFi study as variations in HiFi-CTI delivery would be functionally similar to those observed in intervention delivery between patients during the course of the study. While variation in HiFi-CTI delivery would impede our ability to examine the effect of a single HiFi-CTI intervention delivery scheme, we are still able to measure the efficacy of treatment assignment with an intent-to-treat analysis. If the fidelity assessment did influence intervention delivery or patient engagement with the Support Specialist (e.g. increased frequency of client case discussion led to increased contact attempts and increased contacts), that can be captured in a per-protocol-effect analysis that accounted for patient adherence to the intervention using the number of contacts per phase. If any change in intervention implementation was of concern given specific parameters

of the intervention, future studies could employ fidelity assessments regularly to maintain consistent intervention delivery.

CONCLUSIONS

Conducting a fidelity assessment during an ongoing trial offers important opportunities to systematically review and identify client, interventionist and team components required for a successful implementation. It can also offer insight into inconclusive study findings, as a fidelity assessment conducted during the study period can identify which intervention delivery components were not optimally implemented and might have influenced the overall study findings. Finally, the improvements in intervention fidelity that occurred as a result of our fidelity assessment conducted midway through the study demonstrates the value of using ongoing fidelity monitoring to ensure intervention quality.

TABLES AND FIGURES

TABLE 4: CRITICAL TIME INTERVENTION PRINCIPALS

CTI Principals	Description
1. Time-limited	The intervention should be no longer than 9 months.
2. Phased approach	There should be a pre-CTI phase followed by three phases of equal duration.
3. Focused	Each phase should focus on specific goals.
4. During transition	The intervention should occur during a period of transition in client's lives that is the same for all clients in program that is defined as "leaving from" or "coming to" (i.e. recurrent homelessness).
5. Care coordination	The intervention uses a phased linking process to connect clients to community-based services.
6. Decreasing intensity	The intervention intensity decreases over time with each phase as community supports assume responsibility.
7. Community-based	Meetings should occur within the client's own community, not in the program office.
8. Strengths-based	The intervention should use a strengths-based, recovery-oriented approach where the Support Specialists conduct phase planning and goal setting via shared decision-making.
9. Familiarity with client	Each Support Specialist should establish familiarity with the client during pre-CTI prior to beginning the intervention.
10. Continuity of care	Intervention continues throughout the 9-month intervention period with the CTI Support Specialist activities tied to the linking process.
11. Small caseloads	Each Support Specialist should have no more than 20 patients at a time. This should be calculated using a weighted system to account for the varying intensity of support required in each of the three CTI phases.
12. Weekly team supervision	The Support Specialists should have a weekly meeting led by an experienced clinician who can provide support and troubleshoot case management approaches.

FIGURE 2: CTI FIDELITY RATING FORM FOR THE HELPING INDIVIDUALS WITH FIREARM INJURIES STUDY ADAPTED CTI INTERVENTION

Fidelity Assessment Scoring System					
	Not Implemented	Poorly Implemented	Fairly Implemented	Well Implemented	Ideally Implemented
	1	**2**	**3**	**4**	**5**
	≤40%	41%-54%	55%-69%	70%-84%	≥84%

		Fidelity Measures	Measures	Score
Assessment Domains	Client-Based Fidelity Items	Intake Assessment and Early Engagement of Client	*Measuring*: In person meeting with patient and completion of the intake form. *Assessed using:* Support Specialist encounter documentation from contacts with patients during pre-CTI that included a description of goal setting.	5
		Community-Based Meetings	*Measuring*: In person meetings, rather than phone calls, with the patient and their community support. *Assessed using*: Encounter documentation.	3
		Intensive Phase 1	*Measuring*: Sufficient meetings with both patient and their community support providers to support the initial intensity required of Phase 1. *Assessed using*: Encounter documentation.	1
		Stepping Back for Sustainability	*Measuring*: Sufficient meetings with both patient and their community support providers to support the transfer of care required of Phase 3. *Assessed using*: Progress notes.	1
		Phased Intervention	*Measuring*: Transition between phases occurs when planned. *Assessed using*: Progress notes and closing notes.	3
		Time-Limited	*Measuring*: The intervention does not last longer than 6 months past hospital discharge. *Assessed using:* Closing notes.	4
		Few Dropouts	*Measuring*: The Support Specialist's engagement did not end earlier than 6 months following hospital discharge. *Assessed using*: Closing notes.	4
	Worker-Based Fidelity Items	Small Caseload Size	*Measuring*: The Support Specialist's weighted* caseload is < 20. *Assessed using*: Phase-Date Form	5
		Quality of CTI Worker's Role	*Measuring*: The Support Specialist conducted ongoing community assessments and interventions in person, were available to patients and their community supports, monitored relationships and encouraged communication between patients and their community supports. *Assessed using*: Support Specialist structured interview and Supervisor-Coordinator focus group.	5
		Quality of Phase Plans	*Measuring*: Limited number of focus areas selected, reason for focus area described and summary of prior efforts. *Assessed using*: Phase Plans.	2
		Quality of Progress Notes	*Measuring*: Sufficient detail on encounter documentation to identify type of contact (e.g. in-person, phone call), who the contact was with (e.g. patient, community support, service provider), description of what was discussed, emerging concerns and next steps.	2

			Assessed using: Encounter documentation.	
		Quality of Closing Note	*Measuring*: The Support Specialist had a final meeting with the client to discuss the end of CTI and transfer-of-care. *Assessed using*: Closing notes.	1
	Team-Based Fidelity Items	Weekly Team Supervision	*Measuring*: Weekly team discussions of patients that allow consistent review of all cases each month. *Assessed using*: Team Supervision Forms.	5
		Quality of Supervision	*Measuring*: Feedback from team members to the Support Specialist includes positive feedback when activities are consistent with the CTI model and alternative suggestions are offered when activities are inconsistent. *Assessed using*: Weekly Team Meeting Observation Form	5
		Quality of Fieldwork Coordination	*Measuring*: Phase Date Form is distributed to team regularly and CTI documentation is reviewed with Support Specialist Supervisors regularly. *Assessed using*: Support Specialist structured interview and Supervisor-Coordinator focus group.	5
Total Fidelity score and rating: 70% of all fidelity items met. Well Implemented				

*Patient caseload is weighted according to their progress through Phase 1, 2 and 3 as patients in Phase 1 require more intensive contact and engagement than patients in Phase 2 or 3.

Note: Each score corresponds to the proportion of specific items met in the worksheet evaluation for each fidelity assessment item.

TABLE 5: DEMOGRAPHIC INFORMATION BY INTERVENTION DOSE GROUP

	No Intervention Dose N=31	Low Intervention Dose N=29	High Intervention Dose N=30	Total N=90	*p*
Patient Age, yrs [$\bar{x}$ (SD)]	29.3(10.0)	31.7(11.0)	32.5(17.0)	31.1(13.0)	0.57
Male [N(%)]	31(100.0)	25(86.2)	22(73.3)	78(86.7)	0.01
Race [N(%)]					0.74
White	14(45.2)	11(37.9)	14(48.3)	39(43.8)	
Black	14(45.2)	14(48.3)	10(34.5)	38(42.7)	
Asian	0(0.0)	2(6.9)	2(6.9)	4(4.5)	
Hawaiian/Pacific Islander	0(0.0)	1(3.4)	1(3.5)	2(2.3)	
American Indian	3(9.7)	1(3.5)	2(6.9)	6(6.7)	
Hispanic [N(%)]	3(9.7)	5(17.2)	5(16.7)	13(14.4)	0.65
Employment [N(%)]					0.53
Working	16(55.2)	19(65.5)	21(70.0)	56(63.6)	
Laid Off	7(24.1)	4(13.8)	3(10.0)	14(15.9)	
Student	1(3.5)	3(10.3)	3(10.0)	7(8.0)	
Retired	0(0.0)	1(3.4)	0(0.0)	1(1.1)	
Other	5(17.2)	2(6.9)	3(10.0)	10(11.4)	
Stable Housing [N(%)]					0.3
Stable	19(63.3)	14(53.8)	24(80.0)	57(66.3)	
Transitional	5(16.7)	7(26.9)	3(10.0)	15(17.4)	
Unstable	6(20.0)	5(19.2)	3(10.0)	14(16.3)	
Injury Intent [N(%)]					0.802
Assault	24 (77.4)	22 (75.9)	20 (66.7)	66(73.3)	
Unintentional	5 (16.1)	6 (20.7)	7 (23.3)	18(20.0)	
Undetermined	2 (6.5)	1 (3.4)	3 (10.0)	6 (6.7)	
Patient Household Income [N(%)]					0.22
<$25K	13(61.9)	15(62.5)	10(40.0)	38(54.3)	
25-50K	7(33.3)	5(20.8)	6(24.0)	18(25.7)	
50-100K	1(4.8)	3(12.5)	6(24.0)	10(14.3)	
>100K	0(0.0)	1(4.2)	3(12.0)	4(5.7)	
Injury Severity Score [$\bar{x}$ (SD)]	8.8(9.0)	11.8(16.0)	11.9(15.0)	10.8(10.0)	0.32
Arrested in Past Year [N(%)]	26(83.9)	21(72.4)	16(53.3)	63(70.0)	0.03

Abbreviations: SD: Standard Deviation; Missing information: Race (n=1), Employment (n=2), Marital Status (n=23), Income (n=20), Arrest in prior year (n=1), ISS (n=12).
Note: Stable housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was their address. Transitional housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was not their address. Unstable housing includes individuals who indicated that they were couch surfing, homeless, or in a shelter.

CHAPTER 3. FIREARM-RELATED BEHAVIORS FOLLOWING FIREARM INJURY: CHANGES IN OWNERSHIP, CARRYING AND STORAGE

INTRODUCTION

Individuals who survive a firearm injury (FI) are at substantially increased risk of subsequent firearm injury,[8] potentially due in part to their firearm-related behaviors such as ownership, carrying and storage. Sustaining a FI may serve as a sentinel event for behavior change; as such, these individuals may also benefit from hospital-based interventions focused on reducing risk of subsequent firearm injury or perpetrating firearm-related crime.[56,57] Prior studies have highlighted the promise of providing interventions among trauma patients for reducing high-risk behavior or subsequent injury. One randomized trial of a brief motivational interview provided at bedside among injury patients with a positive blood alcohol level found a reduction in alcohol consumption and approximately 50% reduction in the risk of subsequent injuries 12 months later.[58] Another randomized trial of a 12-month collaborative care intervention of a multidisciplinary care management team found a significant reduction in weapon carrying among injured youth.[20]

There is a dearth of literature examining what, if any, firearm-related behavior changes occur among adults following a FI. To our knowledge, there is currently no standardized and widely-adopted hospital-based assessment of firearm-related behaviors nor hospital-based intervention specifically to promote firearm safety among FI patients. In this study, we sought to describe changes in firearm-related behaviors among FI patients following their injury. Understanding if, and what type of, firearm-related behavior change occurs following a FI can support development of interventions to improve firearm safety among these patients, potentially decreasing their elevated risk of subsequent FI injury or death.

METHODS

We added a firearm-related behavior survey supplement to the regular follow-up surveys in March 2017. At the time of this analysis, 232 patients had been enrolled in the trial (5 of whom had completed the study prior to the addition of these questions and who did not have an opportunity to respond) and 163 answered the firearm-related behavior survey supplement. The study intervention, consisting of case-management for 6 months using an adapted Critical Time Intervention, is designed to improve patients' general health and wellbeing following injury, with a focus on reducing recidivism, but is not focused specifically on firearm-related behaviors.[39] Among patients who answered the firearm survey supplement, there were a total of 86 patients (52.8%) enrolled in the intervention arm of the study.

After the addition of the firearm-behavior survey supplement, patients were given questions on both pre-injury and post-injury firearm ownership, carrying and storage practices at the next regular follow up, regardless of whether the next follow up post survey roll out was 1, 3, 6, 9 or 12 months post-discharge. Pre-injury firearm behavior questions pertained to their firearm related behavior in the 30 days prior to their injury, while post-injury firearm behavior questions pertained to the 30 days prior to this survey. The firearm-related behavior survey supplement also included a comment box that some patients used to provide additional thoughts and feedback (Appendix E).

DEFINING FIREARM BEHAVIOR

Using the pre-injury and post-injury surveys, we defined a series of firearm-related behavior change variables. *Firearm ownership change* was defined as becoming a firearm owner or conversely selling or giving away all of their firearms after injury. Remaining a firearm owner, but changing the number of firearms owned was not included as ownership change. *Change in*

carrying behavior was defined as either beginning to carry a loaded handgun in public, changing the frequency of carrying a loaded handgun in public including stopping any carry, obtaining a concealed carry weapons (CCW) permit, changing how frequently a loaded handgun was carried concealed, or changing the primary reason for carrying a firearm in public. Change in carrying behavior focuses specifically on handguns, as long guns are not as often carried in public. *Change in storage behavior* was defined as changing the location of firearm storage or initiation of safe storage (i.e. all firearms stored locked and unloaded). We then categorized behavior change into three categories: increasing firearm exposure, decreasing firearm exposure and no change in firearm-related exposure. *Increasing firearm exposure* included becoming a firearm owner, initiating carrying a loaded handgun in public, increasing the number of days a loaded handgun was carried in public, increasing frequency of carrying a loaded handgun concealed and obtaining a concealed weapons permit. *Decreasing firearm exposure* was categorized as becoming a non-firearm owner, ceasing to carry a loaded handgun in public, decreasing the number of days a loaded handgun was carried in public, carrying a loaded handgun concealed less frequently, and initiating safe storage. *No change in firearm exposure* was defined as having neither increasing or decreasing firearm exposure. No patients included in our study reported both increasing and decreasing firearm exposure, thus these categories represent mutually exclusive groups.

We additionally defined 6 mutually exclusive and collectively exhaustive groups for both pre-injury and post-injury firearm-related behavior separately to allow exploration of movement between pre-injury group membership and post-injury group membership. These groups were: 1) non-firearm owners, 2) firearm owners who do not carry a loaded handgun in public and who practice safe storage of all firearms, 3) firearm owners who carry a loaded handgun in public and who practice safe storage of all firearms, 4) firearm owners who do not carry a loaded handgun in

public and who do not practice safe storage of all firearms, 5) firearm owners who carry a loaded handgun in public and who do not practice safe storage of all firearms, and 6) firearm owners with unknown carrying and storage behavior. Patients who owned only long guns were placed into groups 2, 4 or 6 depending on their storage behavior.

Analysis

We used descriptive statistics to assess any firearm-related behavior change among the 163 patients who responded to the firearm-related behavior survey supplement during one of their regular follow-up surveys. Using the Pearson's chi-squared test, we tested for an intervention effect, comparing patients in the intervention arm to patients in the control arm of the parent study, and tested if reported-firearm related behavior change varied by the time between sustaining a FI and survey completion. Among patients who reported owning a firearm at the time of injury, we calculated the proportion and 95% confidence intervals (CI) of each firearm-related behavior change. To illustrate patient flow between firearm behavior groups at pre-injury and post-injury assessment points, we used a Sankey diagram [59]. Finally, we qualitatively described FI incident circumstances as well as pre-injury and post-injury firearm-related behavior for a non-random selection of patients reporting behavior change to illustrate the variety of responses and reported incident characteristics. Analyses were conducted in Stata 14.2 and Highcharts.[60]

Results

As stated above, of the 232 patients enrolled in the parent study, 163 completed the firearm-related behavior survey (response proportion of 70.3%). There was no statistically significant intervention effect on firearm-related exposure change (p=0.312). Among intervention patients, 4.7% reported increasing firearm exposure, 18.6% reported decreasing exposure and 76.7% reported no change in firearm exposure compared to 3.9% of control patients who reported increasing exposure, 11.7% who reported decreasing exposure and 84.4% who reported no change

(p=0.445). Therefore, for the remainder of the analysis, the intervention and control groups were combined. About one-half of patients completed the survey one month following hospital discharge (54.0%), with a mean time from hospital discharge to survey completion of approximately 4 months, with the majority completing the survey at the one-month follow up (54.0%) and only 12.3% completing the survey 12 months after their FI (Table 7). The timing of survey completion also did not appear to be associated with reporting firearm-related exposure change (p=0.664).

The majority of patients reported no change in firearm exposure (80.4%); 4.3% of patients reported an increase in firearm exposure and 15.3% of patients reported a decrease in firearm exposure. PTSD scores were highest among patients with decreasing firearm exposure compared to patients with increasing firearm exposure and patients with no change in firearm exposure. A greater proportion of patients who reported no change in firearm exposure had an assault related FI compared to patients with increasing firearm behavior and patients with decreasing firearm behavior. Fewer patients with decreasing firearm exposure reported arrest in the year prior to their FI, while arrest in the prior year was more common among patients with increasing firearm exposure and no change in firearm exposure (Table 6).

In part as a reflection of how we categorized firearm exposure groups, a smaller proportion of patients who reported no change in firearm ownership owned a firearm at the time of injury (16.8%) compared to patients who increased firearm exposure or decreased firearm exposure (Table 1). Patients who were non-firearm owners at the time of their injury would not have been eligible for a change in firearm carrying or storage practices unless they became a firearm owner, whereas patients who were firearm owners at the time of injury were eligible to change ownership, storage and carrying practices.

As shown in Table 8, among the 53 patients who reported owning a firearm at the time of their injury, 60.3% (95% CI: 46.5-72.7) reported any firearm behavior change since hospital discharge. A total of 28.3% (95% CI: 17.7-42.0) became non-firearm owners and 5.7% (95% CI: 1.8-16.4) initiated safe firearm storage (all firearms locked and unloaded), with one of the patients initiating safe storage using the open text field to write "safety first!". Fifteen patients, of whom 7 also became non-firearm owners, stopped carrying a loaded handgun in public (28.3%, 95% CI: 17.7-42.0). Among the 110 patients who were non-firearm owners at the time of injury, 1 patient reported change in firearm-related behavior by becoming a firearm owner (0.9%, 95% CI: 0.1-6.3). Among patients who became non-firearm owners (n=15), patients cited a personal concern for safety, their partner's concern for safety, or concern for the safety of children in the house as the primary motivation. Patients also describe initiation of safe storage practices, and in one case, indicate that their firearm-related behavior change was non-voluntary (firearms were seized as parole violation) (Table 9). While Table 3 does not include every patient who reported behavior change, it does describe behavior change in the context of injury circumstances and illustrates the variety of patient behavior and firearm-related behavior responses to a non-fatal FI.

The Sankey diagram (Figure 3) illustrates the diversity of firearm-related behavior change following FI among patients who reported owning a firearm at the time of injury. Patients who shared the same firearm-related behavior group pre-FI did not all report the same type of firearm-related behavior change or group membership post-FI. The figure also visually demonstrates that there were more patients with decreasing firearm exposure than increasing firearm exposure. There was a single individual in both the pre- and post-FI firearm behavior groups who was a firearm owner who carried a loaded handgun in public and practiced safe storage, these were not the same people. The Sankey diagram illustrates that patients who were firearm owners, carried loaded

handgun in public and did not practice safe storage reported more diversity in behavior change than patients in other pre-FI firearm behavior groups, splitting into four different firearm behavior groups post-FI. There was also diversity in pre-FI firearm-related behavior group membership among patients who became non-firearm owners, patients were owners who carried in public and practiced safe storage, owners who carried a loaded handgun in public and did not practice safe storage and owners with unknown carrying and storage behavior.

DISCUSSION

While some prior literature has examined firearm-related behavior among youth following an assault-related injury,[57] this study offers one of the first descriptions of change in firearm-related behavior among adults following a FI. Our results suggest that while most patients with a FI do not change their firearm-related behavior following injury, some firearm owners with a FI may change their firearm-related behaviors following injury either by decreasing firearm exposure (i.e. removal of firearms and/or initiating safe storage) or increasing firearm exposure (i.e. increasing frequency of carrying a loaded handgun in public).

Patients who sustain a FI may be well suited for either brief hospital-based interventions or integrated collaborative care interventions with a focus on increasing firearm safety, potentially including education and provision of safe storage options, and using the FI as a sentinel event. Such an intervention would likely be most effective if provided exclusively to patients who own a firearm at the time of their injury as they are in a position to make changes to their firearm practices and over half reported some change in firearm-related behavior (60.3%). Non-firearm owners, on the other hand, are likely to remain non-firearm owners and thus, not likely to report any change in firearm-related behavior. Demographic differences between patients with and without any firearm-related behavior change may indicate a subpopulation of FI patients who may be most

receptive to a targeted intervention. Patients with behavior change were likely to have higher mean PTSD symptom scores and have a non-assault related FI when compared to patients without any reported behavior change. Given our small sample size, observed differences between our firearm behavior groups are quite sensitive to individual patient responses and may be different in a larger population of patients with a FI. However, if true, the higher mean PTSD symptom score among patients with reported behavior change would warrant future study and investigation to determine its relationship with injury characteristics and firearm-related behavior.

Among patients with firearm-related behavior change, patients either increased or decreased their firearm exposure following their FI. These behavior changes may not necessarily be related to perceived risk of future injury. Patients with increasing firearm exposure may be driven by a fear-based response, as they may see increasing firearm use as a method for deterring future firearm-based violence.[61] This motivation for increasing firearm exposure may be most likely among those with assault related injury. One patient with increasing firearm exposure carried a loaded handgun in public for 5 out of the 30 days prior to their injury, but after their injury began carrying a loaded handgun in public every day "to protect themselves". Increasing firearm exposure may not necessarily indicate an increased risk of future firearm violence or FI, but it may suggest one of several mechanisms by which patients with a FI are at higher risk of subsequent FI, crime or death. Patients with decreasing firearm exposure may be similarly driven by a fear-based response. In our study, patients with decreasing firearm exposure may have seen their pre-FI firearm exposure as a cause of their FI and chosen to decrease their firearm exposure as a means to prevent potential future firearm-related injury.

While there are currently no standardized, widely-adopted interventions specifically tailored toward firearm-related behavior change among FI patients, behavior change counseling

among youth in the emergency department, motivational interviewing among patients with a motor vehicle crash injury, and stepped collaborative care for trauma patients have all been shown to decrease behaviors associated with subsequent injury (e.g., decreasing alcohol use).[58,62,63] It is possible that a focused intervention with similar features might demonstrate similar success at increasing firearm safety behavior among FI patients (e.g. increasing safe storage) as a means to reduce risk of subsequent injury.

Reliability of Responses: This study relies on self-report of firearm-related behaviors, and may be subject to social desirability bias and intentional false-reporting. Two patients disclosed owning firearms to the study interventionist, but told her that they would be reporting they were not firearm owners. We have excluded them from the analysis. We also believe that there may have been some misclassification of injury intent, as some of the behavior change reported does not seem to logically follow in response to the description of the incident. For example, Patient G described shooting themselves unintentionally while transporting the firearm at their house, thinking the safety was on. Following their FI, they began carrying a loaded handgun concealed in public every day (and did not change their storage practices) potentially a more logical response to an assault (Table 3). The misclassification of FI injury intent, especially for FI reported as being unintentional, has been discussed in the literature before as potentially driven by "antisnitch" codes of silence and may often be truly assault-related.[64]

Although intentional false-reporting may have occurred among some patients regarding firearm-related behaviors and injury circumstances, we have reason to believe that other patients reported firearm-related behavior change honestly, as evidenced by reporting of illegal carrying practices and additional open-ended comments of their reported-behavior on our survey questions. Patient B reported police seizure of their firearms and disclosed illegal concealed carrying before

their FI (Table 3). An assault patient disclosed considering purchasing a firearm, although they had not yet purchased one at the time of the survey. One patient who reported no longer carrying a loaded handgun in public after their injury voiced concern over the survey firearm questions explicitly: "*I am somewhat concerned with this line of questioning, and I am curious what this information is to be used for. It has been my experience in the past that information such as this can be easily used to mislead specific people, or the public, due to the ease at which it can be manipulated*." This concern, and the intentional misreporting of firearm ownership and FI injury intent, highlight the importance of developing rapport with FI patients when inquiring about their firearm-related behaviors to improve data quality.

LIMITATIONS

As this study is nested within an ongoing study, our patient population represents a subset of the broader FI patient population and is limited to adult English-speakers residing in five counties in Washington State. Furthermore, we limited our analysis to those who responded to the firearm survey supplement, excluding patients who were lost to follow up. A greater proportion of patients who responded were more likely than patients who did not respond to the survey to have stable housing, not report arrest in the year prior to injury and have a lower ISS score, all of which may impact firearm-related behavior, and may additionally vary with respect to potential firearm-related behavior change (Appendix F). Additionally, there was some missingness in self-reported demographic information and standardized assessment scores that varied by variable. This is reflective of individual patient desire to respond to that particular question, as each question in our survey was voluntary and often included both a "Do not wish to respond" or "Unknown" option, both coded as missing. Patients with missing responses may be different than patients without missing responses and, given our small sample size, skew our understanding of the underlying

patient population. However, there was differential missingness by variable, allowing for improved confidence in variables with low levels of missingness.

We relied on self-report of firearm-related behavior which, as discussed above, may be subject to information bias. Our study may additionally be subject to recall bias, another form of information bias, as patients were asked to report their pre-FI firearm-related behavior on average 4 months after hospital discharge. However, we believe that the firearm-related behaviors included in our survey (e.g. did they own a firearm at the time of their injury or not) are less vulnerable to recall bias, especially as these behaviors are related to a significant life-event (i.e. FI).

There was no statistically significant intervention effect observed in this study. This was expected, as while the intervention may indirectly influence firearm exposure through its focus on reducing recidivism, the intervention is not designed to specifically address firearm ownership, carrying practices or storage. However, our study sample was relatively small and the parent study was not powered to look at firearm behavior change specifically. Being underpowered for our outcome of interest may have led us to falsely conclude there was no difference between intervention arm or in the timing between survey completion and reported firearm related behavior change, and prevents a stratified analysis by injury intent. Our small sample size also means each reported proportion is quite sensitive to the number of patients with that particular characteristic or reported firearm-related behavior, and a change in response of one or two patients may alter the observed statistical significance.

Notwithstanding these limitations, this study offers the first look into firearm-related behavior change among adult FI patients and offers hypothesis generating data for future research. Even without broad generalizability, the findings offer unique insight into behaviors of a population at high risk for subsequent FI injury.

CONCLUSION

This study highlights the need for further examination of firearm-related behavior change in FI patients and development of interventions to promote firearm safety among this population, especially as some of them may already be considering firearm-related behavior change. Additional work should be done to understand specific rationale for firearm-related behavior change to inform development of interventions that speak specifically to motivators for firearm-related behavior change among FI patients.

TABLES AND FIGURES

TABLE 6: DEMOGRAPHIC INFORMATION BY SELF-REPORTED FIREARM-RELATED BEHAVIOR CHANGE FOLLOWING FIREARM INJURY

	Increasing Firearm Exposure N=7	Decreasing Firearm Exposure N=25	No Change in Firearm Exposure N=131	Total N=163
Patient Age, yrs [$\bar{x}$ (SD)]	25.9 (9)	31.0 (12)	29.9 (10)	29.9 (10)
Male [N(%)]	7 (100.0)	22 (88.0)	108 (82.4)	137 (84.0)
Race [N(%)]				
White	4 (57.1)	13 (52.0)	56 (44.1)	73 (45.9)
Black	2 (28.6)	10 (40.0)	54 (42.5)	66 (41.5)
Asian	0 (0.0)	1 (4.0)	6 (4.7)	7 (4.4)
Hawaiian/Pacific Islander	0 (0.0)	0 (0.0)	3 (2.4)	3 (1.9)
American Indian	1 (14.3)	1 (4.0)	8 (6.3)	10 (6.3)
Hispanic [N(%)]	3 (42.9)	3 (12.0)	15 (11.5)	21 (12.9)
Employment [N(%)]				
Working	5 (71.4)	14 (60.9)	71 (55.9)	90 (57.3)
Laid Off	1 (14.3)	4 (17.4)	25 (19.7)	30 (19.1)
Student	0 (0.0)	2 (8.7)	14 (11.0)	16 (10.2)
Homemaker	0 (0.0)	1 (4.3)	2 (1.6)	3 (1.9)
Retired	0 (0.0)	0 (0.0)	1 (0.8)	1 (0.6)
Other	1 (14.3)	2 (8.7)	14 (11.0)	17 (10.8)
Patient Marital Status [N(%)]				
Single	1 (33.3)	11 (47.8)	57 (50.0)	69 (49.3)
Married	0 (0.0)	3 (13.0)	17 (14.9)	20 (14.3)
In a relationship or dating	2 (66.7)	9 (39.1)	40 (35.1)	51 (36.4)
Patient Household Income [N(%)]				
<$25K	1 (20.0)	4 (23.5)	45 (51.1)	52 (43.3)
25-50K	3 (60.0)	4 (23.5)	28 (28.6)	35 (29.2)
50-100K	0 (0.0)	7 (41.2)	14 (14.3)	21 (17.5)
>100K	1 (20.0)	2 (11.8)	9 (9.2)	12 (10.0)
Stable Housing [N(%)]	5 (71.4)	18 (72.0)	91 (70.0)	114 (70.4)
Arrested in Past Year [N(%)]	1 (14.3)	2 (8.3)	23 (17.6)	26 (16.0)
PCL-C score [$\bar{x}$ (SD)]	24.6 (8)	40.4 (22)	33.7 (16)	34.4 (17)
PHQ-8 depression score [$\bar{x}$ (SD)]	4.3 (5)	8.0 (7)	6.1 (6)	6.3 (6)
MPSS total score [$\bar{x}$ (SD)]	5.9 (1)	4.9 (1)	5.3 (1)	5.2 (1)
Happiness score [$\bar{x}$ (SD)]	89.7 (28)	80.8 (25)	83.5 (26)	83.4 (26)
SF12 Physical Score [$\bar{x}$ (SD)]	54.3 (3)	52.4 (8)	50.0 (11)	50.6 (10)
SF12 Mental Score [$\bar{x}$ (SD)]	54.3 (7)	47.5 (15)	48.5 (13)	48.9 (13)
Alcohol AUDIT score [$\bar{x}$ (SD)]	3.0 (4)	3.8 (3)	3.0 (3)	3.1 (3)
ASSIST Lifetime drug use [N(%)]				
Cannabis	6 (85.7)	19 (79.2)	114 (87.0)	139 (85.8)
Cocaine	3 (42.9)	15 (62.5)	56 (42.7)	74 (45.7)
Prescription stimulants	0 (0.0)	6 (25.0)	32 (24.6)	38 (23.6)
Methamphetamine	0 (0.0)	7 (29.2)	25 (19.1)	32 (19.8)

Inhalants	0 (0.0)	2 (8.3)	5 (3.9)	7 (4.4)
Sedatives or sleeping pills	1 (14.3)	5 (21.7)	33 (25.6)	39 (24.5)
Hallucinogens	2 (28.6)	7 (29.2)	47 (35.9)	56 (34.6)
Street opioids	0 (0.0)	2 (8.3)	17 (13.1)	19 (11.8)
Prescription opioids	3 (42.9)	8 (33.3)	60 (45.8)	71 (43.8)
Injury Intent [N(%)]				
Assault	5 (71.4)	13 (52.0)	101 (77.7)	119 (73.5)
Unintentional	2 (28.6)	11 (44.0)	20 (15.4)	33 (20.4)
Undetermined	0 (0.0)	1 (4.0)	9 (6.9)	10 (6.2)
Injury Severity Score [$\bar{x}$ (SD)]	12.7 (9)	8.8 (6)	9.3 (8)	9.4 (8)
Gun Owner at Time of Injury [N(%)]	6 (85.7)	25 (100.0)	22 (16.8)	53 (32.2)

Abbreviations: SD: Standard Deviation; PCL-C: PTSD Checklist Civilian Version (post-traumatic stress symptoms); PHQ-8: Patient Health Questionnaire (depression); MPSS: Multidimensional Scale of Perceived Social Support (social support); SF-12: Short Form Health Survey (health-related quality of life); AUDIT: The Alcohol Use Identification Test (alcohol use); ASSIST: Alcohol, Smoking and Substance Involvement Screening Test (drug use).

Missingness: Race (n=4), Employment (n=6), Marital Status (n=23), Income (n=43), Arrest in prior year (n=1), MPSS (n=1), Happiness (n=1), SF-12 physical (n=4), SF-12 mental (n=4), ASSIST Cannabis (n=1), Cocaine (n=1), Prescription stimulants (n=2), Methamphetamines (n=1), Inhalants (n=5), Sedatives (n=4), Hallucinogens (n=1), Street opioids (n=2), Prescription opioids (n=1), Injury Intent (n=1), ISS (n=2).

Note: Stable housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was their address. Transitional housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was not their address. Unstable housing includes individuals who indicated that they were couch surfing, homeless, or in a shelter.

TABLE 7: TIMING OF SURVEY COMPLETION AMONG PATIENTS WHO COMPLETED THE FIREARM SURVEY SUPPLEMENT (N=163).

Time since Firearm Injury	No Change Reported N=130 N (%)	Any Change Reported N=33 N (%)	Total N=163 N (%)
1 month	72 (55.4)	16 (48.5)	88 (54.0)
3 months	22 (16.9)	4 (12.1)	26 (16.0)
6 months	10 (7.7)	4 (12.1)	14 (8.6)
9 months	12 (9.2)	3 (9.1)	15 (9.2)
12 months	14 (10.8)	6 (18.2)	20 (12.2)

TABLE 8: FIREARM-RELATED BEHAVIOR CHANGE OBSERVED AMONG FIREARM OWNERS AT TIME OF INJURY

	Firearm Owners at Time of Injury N= 53	
	N	Proportion (95% Confidence Interval)
Any Firearm Behavior Change	32	60.3 (46.5-72.7)
Became a Non-Firearm Owner	15	28.3 (17.7-42.0)
Carrying Change	15	28.3 (17.7-42.0)
Began Carrying in Public	1	1.9 (0.3-12.6)
Stopped Carrying in Public	15	28.3 (17.7-42.0)
Increased Number of Days Carried in Public	1	1.9 (0.3-12.6)
Increased Frequency of Concealed Carry	2	3.8 (0.9-14.2)
Changed Primary Reason for Carrying	9	17.0 (9.0-29.8)
Obtained a CCW Permit	7	13.2 (6.3-25.5)
Storage Change	7	13.2 (6.3-25.5)
Changed storage location	4	7.5 (2.8-18.7)
Initiated Safe Storage	3	5.7 (1.8-16.4)

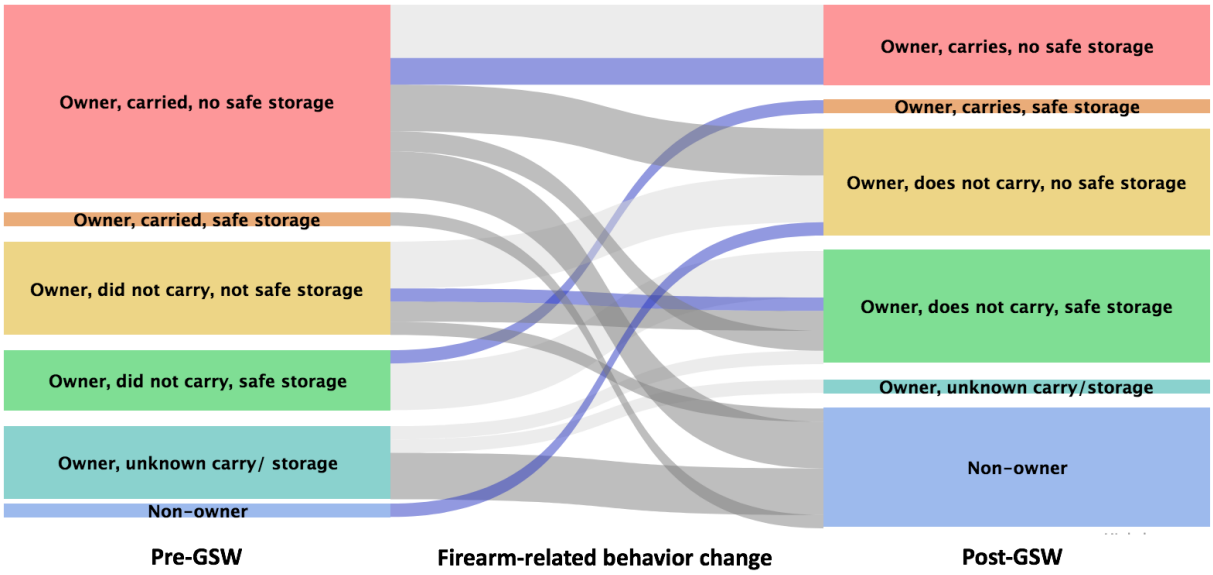
Note: One patient became a firearm owner following their injury, they are not included in this table as they were not a firearm owner at the time of injury.

TABLE 9: DESCRIPTION OF FIREARM BEHAVIOR CHANGE FOR A SELECTION OF PATIENTS WITH SELF-REPORTED FIREARM BEHAVIOR CHANGE

Patient	Firearm behavior pre-FI	Description of incident	Firearm-related behavior post-FI
A	*Firearm ownership*: Multiple firearms, multiple types *Ownership primary reason*: Protection *30-day carry*: Every day *Carried concealed:* Always *CCW permit*: Yes *Storage type*: Not practicing safe storage *Storage location*: Multiple locations	*Incident type:* Intentional inter-personal. *Notes*: Patient was carrying one of the firearms at the time and both displayed the gun and shot the gun in an attempt to defend themselves.	After the injury, patient began storing all guns either loaded and locked or loaded and unlocked. Patient's carrying practices did not change.
B	*Firearm ownership*: Multiple firearms, multiple types *Ownership primary reason*: Protection *30-day carry*: Every day *Carried concealed*: 75% of the time *CCW permit*: No *Storage type*: Safe storage *Storage location*: Home	*Incident type:* Intentional inter-personal.	After the injury, patient was arrested on a violation of parole and no longer have any of their firearms. States now trying to change their life.
C	*Firearm ownership*: Single firearm *Ownership primary reason*: Protection *30-day carry*: Every day *Carried concealed*: Always *CCW permit*: Yes *Storage type*: Not practicing safe storage	*Incident type:* Unintentional self-inflicted *Notes:* Thought the firearm was unloaded.	After the injury, patient got rid of the firearm (unknown how).

	Storage location: Home		
D	*Firearm ownership*: Multiple firearms, multiple types *Ownership primary reason*: Collection *30-day carry***:** Every day *Carried concealed*: Always *CCW permit*: Yes *Storage type*: Not practicing safe storage *Storage location*: Home	*Incident type:* Unintentional self-inflicted *Notes*: Shot while hunting.	Since being shot, patient has not carried a loaded handgun in public and the handgun that was stored loaded and unlocked is now stored loaded and locked.
E	*Firearm ownership*: Owner, unknown type or number *Ownership primary reason*: Unknown *30-day carry*: Unknown *Carried concealed*: Unknown *CCW permit*: Unknown *Storage type*: Unknown *Storage location*: Unknown	*Incident type:* Intentional inter-personal.	Patient sold the firearm after the injury as patient was worried 'they might shoot somebody.'
F	*Firearm ownership*: Single firearm *Ownership primary reason*: Protection *30-day carry*: Every day *Carried concealed*: Always *CCW permit*: Yes *Storage type*: Not practicing safe storage *Storage location*: Home	*Incident type:* Unintentional self-inflicted	Since the injury, patient has not carried the firearm in public. The firearm is now stored unloaded and locked.
G	*Firearm ownership*: Multiple firearms, multiple types *Ownership primary reason*: Protection *30-day carry*: No *CCW permit*: No *Storage type*: Safe storage *Storage location*: Home	*Incident type:* Unintentional self-inflicted *Notes*: Thought the safety was on.	After the injury, patient sold old firearms and purchased new firearms for collection purposes. Patient began carrying a loaded handgun in public every day for protection and always carried it concealed. Patient obtained a concealed carry weapons permit. Patient's storage practices have not changed.

FIGURE 3: SANKEY DIAGRAM OF FIREARM-RELATED BEHAVIOR CHANGE BEFORE AND AFTER FI AMONG PATIENTS WHO OWNED A FIREARM EITHER AT THE TIME OF THEIR INJURY OR SUBSEQUENTLY (N=54)



Key:

- Increasing firearm exposure
- Decreasing firearm exposure
- No change in firearm exposure

Interpretation: The left and right-hand side of the Sankey diagram display the firearm behavior group that patients belonged to pre- and post-FI, respectively, among patients who reported owning a firearm at the time of injury. The thickness of the lines connecting the left and right-hand sides of the diagram illustrate the absolute number of patients who moved from each pre-FI firearm behavior group to each post-FI firearm behavior groups. The colors used for the lines that connect the pre- and post-FI firearm behavior groups indicate the whether or not the change increased firearm exposure, decreased firearm exposure, or did not change firearm exposure.

Note: There are seven people whose firearm-related behavior increased (indicated with the lavender lines), but only two changed firearm behavior groups. This is because the firearm behavior groups are based on only ownership, whether or not an individual carried a firearm at all in the 30 days prior to the injury and whether or not they practiced safe storage, and did not consider the other firearm-related behaviors (e.g. obtaining a CCW, increasing the number of days they carried a handgun in public).

Discussion

In this dissertation, we analyzed a randomized controlled trial and conducted two nested studies within the parent study to assess both the potential for change in this patient population and to measure the quality of intervention delivery. In Chapter 1, we did not find an effect of the intervention on either arrest or subsequent injury even after rigorous outcome data ascertainment. However, HiFi-CTI and CTI are less intensive than other hospital- and community-based violence intervention programs which have been effective at reducing subsequent violence. Chapter 2 describes the fidelity assessment of the HiFi intervention which found HiFi-CTI to be well implemented according to guiding CTI principals. Chapter 3 illustrated the variety of behavior changes reported by patients following a firearm injury, and the potential opportunity for behavior change interventions in this patient population. Taken together, this dissertation suggests that patients with a firearm injury may be open to behavior change following injury, but that the HiFi-CTI intervention was not sufficient to change risk of subsequent arrest or injury. As HiFi-CTI was found to be well implemented, it is likely that CTI, while designed to be applied to multiple contexts and populations of people during a critical time in their life, is not ideally suited to support patients with firearm injury.

This work has many strengths. It represents a thorough evaluation of the first community-based intervention of randomized controlled trial conducted exclusively among patients with a FI. We conducted extensive administrative data linkages to measure subsequent arrest and injury and capture censoring times when the patient was not in the community or at risk for developing the outcome. We also developed and piloted a new survey tool to assess firearm-related behavior change around a sentinel event, which can be employed in other contexts to measure behavior change. Finally, we conducted a fidelity assessment to provide transparency into how HiFi-CTI

was implemented. This allowed us to both ensure that our null findings were not due to poor intervention implementation, but also illustrates how future interventions in this population could be tailored to improve patient engagement.

In conclusion, patients with firearm injuries are potentially open to interventions that support behavior change. However, the CTI model is likely not intensive enough to change the high risk of subsequent arrest and injury in this population. Future studies aimed at reducing arrest and injury should use more intensive approaches.

APPENDIX A: CONSORT DIAGRAM

Gunshot Wound Victims Presented to HMC (146 weeks; n=855)

Randomized (146 weeks)

Intervention Week (n=437 people; 73 weeks)
- Did not meet inclusion criteria (n=279, 63.8%)
- Enrolled (n=118, 27.0%)
- Declined to participate/withdrew (n=40, 9.2%)

Control Week (n=418 people; 73 weeks)
- Did not meet inclusion criteria (n=283, 67.7%)
- Enrolled (n=114, 27.3%)
- Declined to participate/withdrew (n=21, 5.0%)

Assigned to CTI (n=118)
Received CTI: set recovery goals and had at least one face-to-face visit in the community (n=73, 61.9%)

Usual Care (n=114)

Progress to Date (n=118)
- Declined CTI (n=3, 2.5%)
- No contact with Support Specialist (n=1, 0.8%)
- Ended pre-CTI only (n-41, 34.7%)
- Ended received CTI (n=73, 61.9%)

Retention for Primary Outcomes (Arrests)
- Stayed in Washington (n=109, 95.6%)
- Moved from Washington (n=5, 4.4%)

Retention for Primary Outcomes (Arrests)
- Stayed in Washington (n=113, 95.7%)
- Moved from Washington (n=5, 4.3%)

Control Week Retention
- Follow-up completed at any time point (n=88, 77.2%)
- No follow-up (unable to locate or participate all time points) (n=26, 22.8%)

Intervention Week Retention
- Follow-up completed at any time point (n=98, 83.1%)
- No follow-up (unable to locate or participate all time points) (n=20, 16.9%)

Helping Individuals with Firearm Injuries (HIFI)
UW Dept. of Epidemiology
Study Cell: 206-446-8914
Study Email: hifihelp@uw.edu

HARBORVIEW MEDICAL CENTER
UW Medicine

Community Resources

EMERGENCY RESOURCES

For Men

Bread of Life Mission 206.682.3579 Ext.100
97 S Main St, Seattle Walk in, M-F, 10am-4pm. Chapel service req'd. $5/night, first 2 nights free.

Compass Housing Alliance .....Walk In Only
Client Services Office, 77 S Washington St, Seattle Walk in, M–F, 9am-4pm. $21/week. Entrance to building is around the corner under the Alaskan Way Viaduct.

Seattle's Union Gospel Mission …206.622.5177
318 2nd Ave Extension S, Seattle Call or walk in, 9am-6:30pm, to reserve a ticket for the night. Those without a ticket can line up for an unclaimed mat at 7:15pm. ID req'd.

Para Español……..206.622.5177 Ext. 473

For Women

DESC 206.464.1570 x3033
517 3rd Ave, Seattle Walk in daily, 7am-4:45pm. Serves women anyone identifying as female.

Hope Place 206.628.2008
3802 S Othello St, Seattle Call for screening, M-F, 8:30-9am. Includes mandatory spiritual activities. $9.08 for credit check.

Hospitality House 206.242.1860
1419 SW 150th St, Burien Call for screening, M-Th, 1-7pm. Serves single women, ages 18 and older. No fees. Can stay up to 3 months.

For Youth

Arcadia House 253.740.7189
915 H Street SE, Auburn Co-ed overnight shelter for young adults, 18-24. Line up outside at 8:30pm for intake. Must leave by 7am.

New Horizons .....206.374.0866 Ext. 209
2709 3rd Ave, Seattle Walk-in Su-Th, 7-8pm for intake. Serves young adults age 18-23. No Pets. ID or Case Manager letter required.

Domestic Violence

DAWN..... 425.656.7867
Call for intake 24 hours, daily. Serves women, including Trans Women, with or without children.

LifeWire……..425.746.1940
Call for intake 24 hours, daily. Survivors may be of any gender, with or without children. Occasionally provides motel vouchers.

To inquire about more Emergency Housing optio s, please call 2-1-1.

WORK

Casa Latina ..... 206.956.0779 Ext. 112
317 17th Ave S, Seattle Mandatory orientation 1st & 3rd M each month, 7am, Photo ID req'd.

Millionair Club 206.728.5627
2515 Western Ave, Seattle Call to see if applications being accepted. Valid state or government ID and Social Security card req'd. Cannot serve felons. Registered clients, walk in: M-Sa, 6-10am.

Please visit: www.crisisclinic.org/education/2-1-1-community-resources/ for resources for Job Seeking Skills, Job Training, and Job Search.

HOUSING

King County Housing Authority
Phone:(206) 574-1248. Hours: Applications Center Phone: M-F, 8am-4:30pm. Management Offices: M-F, 9am-noon. www.kcha.org
Operates public housing properties throughout King County, excluding Seattle and Renton. serves low-income households. Housing Choice Voucher (Section 8) rental subsidies for very low-income households.

Housing Search Northwest
Phone: (877) 428-8844. Hours: M-F, 6am-5pm. www.housingsearchnw.org Provides searchable, real-time listings of available low- and market-rate housing, including senior housing options.

HOT MEALS

Bread of Life Mission.206.682.3579, Ext 100
97 S Main, Seattle Lunch: M-F, 12:15pm. Dinner : M-Sa, 5:30pm. Optional Chapel Service at 6:30. Serves adults and families.

El Centro de la Raza 206.973-4401
2524 16th Ave S, Seattle M-F, noon-1pm. Serves anyone in need.

Millionair Club 206.728.5627
2515 Western Ave, Seattle Breakfast: M-F, 6:15-7am. Lunch: M-F, Noon-1:30pm. Serves anyone in need.

Union Gospel Mission ……..206.622.5177
318 2nd Ave Extension S, Seattle Daily, 7-8:30am, noon-12:45pm, 5-5:30pm, 5:30-6:30pm. No noon meal Su. Serves anyone in need.

EDUCATION

FamilyWorks……..(206) 694-6727
Address:1501 N 45th St, Seattle, WA, 98103. Hours: M, 9:30am-noon; Tu-Th, 9:30am-5pm; F, 9:30am-3pm. Provides pre-employment services to anyone. Offers one-on-one employment advice, public computer availability for Internet job search and computer tutoring.

Goodwill Adult Education……..(206) 860-5791
Address:700 Dearborn Pl S, Seattle, WA, 98144. Hours: M-F, 8:30am-4:30pm. Provides adult basic education, including computer classes, GED preparation and ESL, to those age 16 and older with multiple barriers to employment. Website: www.seattlegoodwill.org

Please visit: www.crisisclinic.org/education/2-1-1-community-resources/ for resources for Computer Classes, ESL Classes, GED Classes, Homeless Student Liaisons, School Supplies, and Tutoring/ Homework Help.

ADDICTION/RECOVERY

Washington Recovery Help Line
Call 1-866-789-1511 (toll-free). 206-461-3219 (TTY). State-wide 24-hour/day support for people dealing with substance abuse, mental health issues; and problem gambling; provides crisis intervention and referrals to treatment & support services in Washington state.

Evergreen Treatment Services 206-223-3644.
www.evergreentx.org/

Harborview: Addictions Treatment Programs
206-744-9657. http://www.uwmedicine.org/locations/addictions-program-harborview

OTHER RESOURCES

Washington State Department of Social and Health Services (DSHS)- Seattle Office: 2106 2nd Ave Seattle, WA 98121. Phone:1-877-501-2233. www.washingtonconnection.org
Call or visit website to apply for government food assistance/EBT, cash assistance, TANF, WIC, childcare, housing, and other benefits.

Harborview Center for Sexual Assault & Traumatic Stress- Address: 401 Broadway, Suite 2075 Seattle, WA 98104. Phone: (206) 744-1600. Center provides direct services, education and consultation for health, mental health, and legal professionals; promotes prevention and works with communities to promote social change.

SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

King County

HARBORVIEW INJURY PREVENTION & RESEARCH CENTER

Arrest

Data Sources. Washington State Patrol (WSP) data is a statewide database of all arrests that occur in WA state. WSP data was sent to HIPRC and linked to HiFi patients. Administrative Office of the Courts (AOC) data is an electronic statewide database that includes information from cases files in most state courts. This is a comprehensive statewide database on all civil and criminal convictions in Washington State. The Seattle Municipal Court does not report infraction data to AOC, although they do share information with WSP.

Linkage. We were provided with all WSP arrest records for any individual in Washington State from 1974 through June 30, 2019. Limiting data to 2011 to capture arrests in the 5 years prior to HiFi enrollment, we used Link King to identify arrest records among HiFi patients matching on first name, last name, middle name, date of birth, sex and race. Link King software was developed to support linking of administrative datasets in Washington State and first uses deterministic matching followed by probabilistic matching. Using the combination of deterministic and probabilistic linkage, Link King categorizes links by level of certainty where Level 1 is 'highest possible', Level 2 is 'very high', Level 3 is 'high', Level 4 is 'moderate to high', Level 5 is 'probabilistic probable twins' and Level 6 is 'probabilistic maybe.' We accepted any match with a Level 1-3 classification and reviewd by hand any matches made with Level 4-6 certainty. Typically, 90% or more of matches are classified at certainty Levels 1 or 2.[75]

For AOC data, we provided AOC data managers with HiFi patient names, date of birth (DOB), sex, address and derived driver's license number for a manual matching process. Following linkage, data for HiFI patients was sent to HIPRC where two trained coders conducted a manual review to exclude non-criminal traffic violations, juvenile offenses and probable cause arrests that resulted in a subsequent arrest to prevent double-counting arrest charges. Remaining arrests and probable cause arrests were included. AOC and WSP data were merged to identify any arrest for HiFi patients prior to enrollment and in the 12 months following enrollment (

Figure 1).

Subsequent Injury

Data Sources. To identify subsequent injuries resulting in hospitalization we used the Comprehensive Hospital Abstract Reporting System (CHARS), which is a database covers discharges from all acute care hospitals in Washington State. It provides ICD coded data on diagnoses and procedures, as well as demographic information, treatment information, and hospital disposition. For injuries resulting in death, we used the Washington State vital statistics files which include name, sex, race, date of birth, date of death, and cause of death.

As there is not yet a comprehensive dataset with all Emergency Department (ED) visits that occur in Washington State, we combined a series of five data sources to ascertain subsequent injuries requiring ED treatment. Our first data source for subsequent injury was the Emergency Department Information Exchange (EDIE) is a program run by Collective Medical Technologies, Inc. which allows hospitals to voluntarily participate in EDIE by reporting Emergency Department (ED) visits. In turn, when a patient presents to an ED at participating hospitals, physicians can see prior ED visits in the past 6 months with short visit summaries as well as an alert generated by the Prescription Monitoring Program of Washington State for long-term prescription opioid use and potential opioid seeking behavior, although all recorded ED visits are retained by Collective Medical Technologies. Hospitals began participating in 2009 in Washington State, and as of 2013, EDIE included all major EDs in the state. EDIE allows the creation of patient groups within their interface to facilitate patient follow up. As patients were enrolled in HiFi, a Research Assistant would add them to the HiFi patient group in EDIE. Collective Medical Technologies built a custom report which queried any ED visit for all HiFi patients in Washington without any date restrictions.

Second, for any ED visits that occurred at the Harborview Medical Center (HMC) or affiliated hospitals, we conducted chart reviews of prior ED visits and any resulting hospitalizations using HMC electronic medical records (EMR) using EPIC. We used Care Everywhere to ascertain ED utilization as our third data source. Care Everywhere

is a data sharing platform integrated into the EPIC electronic health record system that was developed to create a more comprehensive health record and improve the speed of care, especially when seeing multiple providers in different hospitals and clinics. For all medical centers using EPIC, a physician can open Care Everywhere and see a log of all patient visits made to other clinics that use EPIC, including the date and location of visit, provider seen and (often) a short chief complaint description. The provider can then query chart notes for previous visits in different hospitals, and can have almost immediate access. Any charts that have been queried by a HMC or affiliated physician as part of care for a patient are then imported into their HMC medical record.

As our fourth data source, we additionally used Amalga, which is a data aggregation platform used by HMC that can be used to any part of the patient's electronic health record that is in EPIC or ORCA. Data was abstracted using a SQL query and included hospital records, ED visits as well as outpatient visits. For each health care encounter, we obtained data on chief complaint, type of service received, date of service and any entered chart notes. As our fifth ED visit data source, we used the Rapid Health Information NetwOrk (RHINO) was developed for syndromic surveillance and is a Washington State Department of Health run real-time ED data. However, it is not yet fully online and initially EDs did not need to report patient name and date of birth, although some did. Patient sex, race and age were reported. We received records from the start of RHINO through June 30, 2019 for any ED visit reported to RHINO.

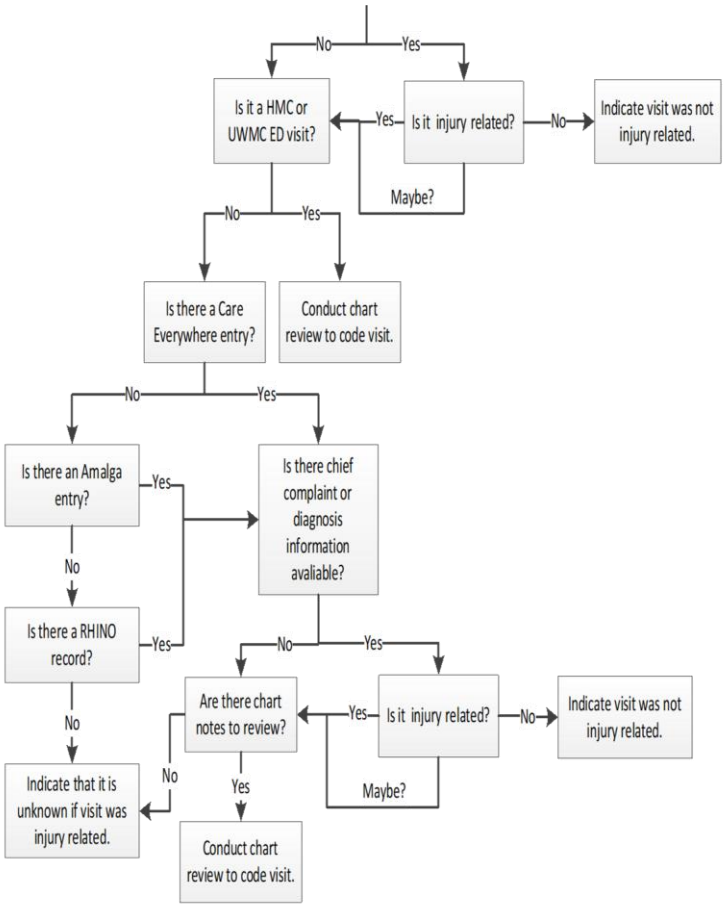


FIGURE 4: PROCESS TO DETERMINE IF ED VISIT WAS INJURY-RELATED

Linking. For CHARS data we conducted a two-step linking process where protected health information (PHI) for all individuals with a hospital visit in Washington State from 2016 through 2018 were sent from the Department of Health (DOH) to HIPRC where they were linked with HiFi patient PHI with Link King using first name, last name, middle name, date of birth, sex and race. Following the linkage, a crosswalk file with unique identifiers for HiFi patients in CHARS was sent to the DOH where it was linked with hospitalization records, which were then sent back to HIPRC for final linking.

Building the state-wide ED visit dataset. For all recorded ED visits, we conducted a structured tiered approach to determine if the visit was injury related beginning with the EDIE generated report on ED visits for HiFi patients (Figure 4). For each ED visit, we coded whether or not the visit was injury related, an incident injury, mechanism, body area, links between multiple ED visits for the same underlying injury and any treatment received for return visits. If the first data source had sufficient information to determine whether or not the visit was injury related, and if so, complete all coding then no additional data sources were used.

Following creation of this ED visit dataset, we merged subsequent ED injury data with CHARS for hospitalization data and Vital statistics for death records.

Jail and Prison Data

Data Sources. We used Jail Booking and Reporting System (JBRS) data from 2016 through June 30, 2019 for Washington State for censoring dates. The JBRS dataset is maintained by the Office of Financial Management for Washington State and includes jail data from all county jails, except for the King County Jail and the Maleng Regional Justice Center in south King County. As King County Jail (KCJ) does not report jail data to JBRS, and the recruitment hospital was in King County, we additionally obtained KCJ data from 2016 through June 30, 2019. KCJ provided us with an additional data file that indicated placement during the incarceration (e.g. work release, secure facility). We did not censor patients time in jail if they were indicated as being on a work release. We did not obtain prison data from the Department of Corrections; however, our Research Assistants would regularly search the Department of Corrections website for HiFi patients to obtain publicly-available incarceration data. Additionally, anytime a patient was unreachable during a follow up window, incarceration in either a jail or prison was noted if endorsed by one of the patient's alternative contacts.

Linkage. For JBRS and KCJ separately, we conducted linking with HiFi patients at HIPRC. As with WSP data, linking was conducted using Link King using first name, last name, middle name, date of birth, sex and race. Once linked with HiFi patients, JBRS and KCJ records were merged and included as censored time for both the analyses of arrest and subsequent injury.

For all matches produced by linking software conducted by investigators, we conducted a manual review for confirmation.

APPENDIX D: STANDARDIZED ASSESSMENTS INCLUDED IN FOLLOW UP SURVEYS

Included in:		Survey scale or item	Measures
Long form	**Short form**		
X	X	Locating questions	Contact information questions to increase likely hood of reaching the subject during the next follow up period
X	X	Patient Health Questionnaire (PHQ-8)[47]	Depression *Note: Short form survey used the PHQ-2*
X	X	Short Form Health Survey (SF-12)[50]	Health-related quality of life *Note: Short form survey included only the overall global health question from the SF-12*
X	X	The Alcohol Use Identification Test (AUDIT)[51]	Risky alcohol use *Note: Short form survey used only the first three questions on the AUDIT survey*
X	X	Alcohol, Smoking and Substance Involvement Screening Test (ASSIST)[52]	Lifetime substance use and substance use disorders
X	X	Critical Time Intervention (CTI) Satisfaction	Satisfaction with the CTI intervention program *Note: Asked only of intervention patients*
X	X	Firearm-related behaviors (Appendix E)	Firearm ownership, carrying and storage behaviors *Note: This module was added March 2017*
X		Posttraumatic Stress Disorder Checklist – Civilian Version (PCL-C)[46]	Posttraumatic stress disorder
X		Impulsive-Premeditated Aggression Scale (IPAS)	Impulsive and premeditated aggressive behavior
X		Conflicts Tactics Scale (CTS)	Interpersonal violence
X		Happiness Scale[49]	Satisfaction with specific areas of life
X		Service utilization questions	Use of physical and mental health services
X		Self-Reported Delinquency (SRD) items of the Pittsburg Youth Study[76]	Criminal justice system involvement, violence, criminal outcomes, conviction(s) and incarceration(s)
X		Multidimensional Scale of Perceived Social Support (MSPSS)[48]	Perceived social support
X		Neighborhood safety questions	Perceived exposure to disorder and violence
X		Education questions	Educational attainment and activities
X		Employment questions	Employment status
X		Housing questions	Type of housing
X		Marital status	Marital status

APPENDIX E: FIREARM SURVEY SUPPLEMENT QUESTIONS
Note: Branching logic is in italics.

Pre-FI Firearm-Related Behavior Questions

Ownership Module - Asked of all participants

This first portion focuses on firearm ownership **at the time you were shot**.

1. Did you personally own a firearm, regardless of whether you carried it with you when you were shot? Yes/No
    a. *(If they owned a firearms)*
        i. How many handguns did you own? _____
        ii. How many long guns did you own? Long guns include rifles, shotguns, semi-automatic rifles: _____
2. *(If they owned a gun)* Please select the primary reason you owned a firearm (check only one):
    a. For protection against strangers
    b. For protection against people I know
    c. For protection against animals
    d. For hunting
    e. For other sporting use
    f. For a collection
    g. It is my right
    h. For some other reason
3. *(If they said 'for some other reason' in question 2.h.)* What was the primary reason you owned a firearm? _____
4. *(If they owned a firearm)* Have you acquired a firearm in the past year? Yes/No

Carrying Module - Asked of participants *who own a handgun*.

Now we would like to ask you about your handgun carrying behavior before your injury.

1. In the 30 days before you were shot, did you ever carry a loaded handgun in public? Yes/No
    a. *(If yes to question 1)* In those 30 days, about how many days did you carry a loaded handgun in public? _____
    b. *(If yes to question 1)* What was the primary reason for carrying (check only one)?
        i. Protection
        ii. Transporting the handgun between two locations
        iii. Intimidation
        iv. Sporting/hunting
        v. For use at work
        vi. Other: _____
    c. *(If they said 'other' for 1.b.vi)* What was your primary reason for carrying:_____
    d. How often did you carry the handgun concealed (check only one)?
        i. Always carried it openly
        ii. Mostly carried it openly (around 75% of the time)
        iii. Were as likely to carry it openly as concealed (around 50% of the time)
        iv. Mostly carried it concealed (around 75% of the time)
        v. Always carried it concealed
2. Did you have a concealed carry weapons permit at the time you were shot? Yes/No

Storage Module - Asked of participants if they owned a gun.

These next questions are about where you stored your firearm(s) at the time of your injury. For these questions, locked can mean the firearm is stored in a lock box, vault or safe or has a cable lock, trigger lock or other personalized lock.

1. Of the firearm/firearms you owned at the time you were shot, where were they usually stored: (please select all that apply)
    a. In your home
    b. In a garage at your home
    c. In another building at your home
    d. In your car or other motor vehicle
    e. At work
    f. At a gun club
    g. Someplace else
2. Of those firearms you owned at the time you were shot, how many were usually stored:
    a. Loaded and unlocked _____
    b. Loaded and locked up _____
    c. Unloaded and unlocked _____
    d. Unloaded and locked up _____

Post-FI Firearm-Related Behavior Questions

Ownership Module - Asked of all participants

This first portion focuses on firearm ownership **currently**.

1. Do you personally own a firearm now? Yes/No
    a. *(If yes to question 1)* How many handguns do you own? _____
    b. *(If yes to question 1)* How many long guns do you own? Long guns include rifles, shotguns, semi-automatic rifles: _____
2. *(If yes to question 1)* Please select the primary reason you own a firearm currently (check only one):
    a. For protection against strangers
    b. For protection against people I know
    c. For protection against animals
    d. For hunting
    e. For other sporting use
    f. For a collection
    g. It is my right
    h. For some other reason: _____
3. (*If 'for some other reason' to question 2.h*) What is the primary reason you own a firearm? _____
4. *(If they own a firearm)* Have you acquired a firearm since your last survey? Yes/No
    a. (*If they have acquired a firearm since the last survey)* What is your primary reason for acquiring a new firearm (check only one)?
        i. For protection against strangers
        ii. For protection against people I know
        iii. For protection against animals
        iv. For hunting
        v. For other sporting use
        vi. For a collection
        vii. For some other reason: _____

b. (*If 'for some other reason' to question 4.a.vii*) What is your primary reason for acquiring a new firearm?

5. Have you gotten rid of a firearm since your last survey? Yes/No/Not applicable
    a. *(If they have gotten rid of a gun since their last survey)* Please select the primary reason you got rid of the firearm (check only one)?
        i. Needed the money
        ii. Didn't see a use for them
        iii. Concerned about safety of children in the house
        iv. I felt uncomfortable about them
        v. My spouse/partner felt uncomfortable about them
        vi. Concerned that a household member might be suicidal or violent
        vii. Some other reason: _____

    b. (*If for 'some other reason" to question 6.a.vii*) What is the primary reason you got rid of the firearm?

Carrying Module - Asked of all participants *who own a handgun*.

Now we would like to ask you about your handgun carrying behavior **in the last 30 days.**

1. In the past 30 days, did you ever carry a loaded handgun in public? Yes/No
    a. *(If yes to question 1)* In the past 30 days, about how many days did you carry a loaded handgun in public? _____
    b. *(If yes to question 1)* What was the primary reason for carrying (check only one)?
        i. Protection
        ii. Transporting the handgun between two locations
        iii. Intimidation
        iv. Sporting/hunting
        v. For use at work
        vi. Other: _____
    c. (If 'other' in question 1.b.vi) What was the primary reason for carrying?
    d. *(If yes to question 1)* How often did you carry the handgun concealed (check only one)?
        i. Always carried it openly
        ii. Mostly carried it openly (around 75% of the time)
        iii. Were as likely to carry it openly as concealed (around 50% of the time)
        iv. Mostly carried it concealed (around 75% of the time)
        v. Always carried it concealed
2. *(If yes to question 1)* Have you obtained a concealed carry weapons permit since the last survey? Yes/No

Storage Module - Asked of all participants if they owned a gun.

These next questions are about where you **currently** store your firearm(s). For these questions, locked can mean the firearm is stored in a lock box, vault or safe or has a cable lock, trigger lock or other personalized lock.

1. Of the firearm/firearms you own currently, where are they usually stored: (please select all that apply)
    a. In your home
    b. In a garage at your home
    c. In another building at your home
    d. In your car or other motor vehicle
    e. At work

f. At a gun club
g. Someplace else

2. Of those firearms you own currently, how many were usually stored:
    a. Loaded and unlocked _____
    b. Loaded and locked up _____
    c. Unloaded and unlocked _____
    d. Unloaded and locked up _____

APPENDIX F: DEMOGRAPHIC INFORMATION BY FIREARM-RELATED BEHAVIOR SURVEY COMPLETION

	Completed survey N=163	Did not complete survey N=69	Total N=232
Patient Age, yrs [$\bar{x}$ (SD)]	29.9 (11)	29.4 (11)	29.8 (11)
Male [N(%)]	137 (84.0)	62 (89.9)	199 (85.8)
Race [N(%)]			
White	73 (45.9)	24 (35.8)	97 (42.9)
Black	66 (41.5)	35 (52.2)	101 (44.7)
Asian	7 (4.4)	3 (4.5)	10 (4.4)
Hawaiian/Pacific Islander	3 (1.9)	5 (7.5)	8 (3.5)
American Indian	10 (6.3)	0 (0.0)	10 (4.4)
Hispanic [N(%)]	21 (12.9)	7 (10.1)	28 (12.1)
Employment [N(%)]			
Working	90 (57.3)	34 (59.6)	124 (57.9)
Laid Off	30 (19.1)	11 (19.3)	41 (19.2)
Student	16 (10.2)	2 (3.5)	18 (8.4)
Homemaker	3 (1.9)	1 (1.8)	4 (1.9)
Retired	1 (0.6)	2 (3.5)	3 (1.4)
Other	17 (10.8)	7 (12.3)	24 (11.2)
Patient Marital Status [N(%)]			
Single	69 (49.3)	19 (47.5)	88 (48.9)
Married	20 (14.3)	9 (22.5)	29 (16.1)
In a relationship or dating	51 (36.4)	12 (30.0)	63 (35.0)
Patient Household Income [N(%)]			
<$25K	52 (43.3)	24 (63.2)	76 (48.1)
25-50K	35 (29.2)	8 (21.1)	43 (27.2)
50-100K	21 (17.5)	4 (10.5)	25 (15.8)
>100K	12 (10.0)	2 (5.3)	14 (8.9)
Stable Housing [N(%)]	114 (70.4)	42 (61.8)	156 (67.8)
Arrested in Past Year [N(%)]	26 (16.0)	18 (30.5)	44 (19.9)
PCL-C score [$\bar{x}$ (SD)]	34.3 (17)	33.2 (17)	34.0 (17)
PHQ-8 depression score [$\bar{x}$ (SD)]	6.3 (7)	5.9 (6)	6.2 (6)
MPSS total score [$\bar{x}$ (SD)]	5.2 (1)	5.1 (1)	5.2 (1)
Happiness score [$\bar{x}$ (SD)]	83.4 (26)	82.7 (31)	83.2 (27)
SF12 Physical Score [$\bar{x}$ (SD)]	50.6 (10)	50.2 (10)	50.5 (10)
SF12 Mental Score [$\bar{x}$ (SD)]	48.6 (13)	49.2 (13)	48.8 (13)
Alcohol AUDIT score [$\bar{x}$ (SD)]	3.1 (3)	2.7 (3)	3.0 (3)
Injury Intent [N(%)]			
Assault	119 (73.5)	53 (77.9)	172 (74.8)
Unintentional	33 (20.4)	8 (11.8)	41 (17.8)
Undetermined	10 (6.2)	7 (10.3)	17 (7.4)
Injury Severity Score [$\bar{x}$ (SD)]	9.4 (8)	11.9 (9)	10.1 (8)

Abbreviations: SD: Standard Deviation; PCL-C: PTSD Checklist Civilian Version (post-traumatic stress symptoms); PHQ-8: Patient Health Questionnaire (depression); MPSS: Multidimensional Scale of

Perceived Social Support (social support); SF-12: Short Form Health Survey (health-related quality of life); AUDIT: The Alcohol Use Identification Test (alcohol use).
Missing information: Race (n=6), Employment (n=18), Marital Status (n=52), Income (n=74), Arrest in prior year (n=11), PHQ-8 (n=7), MPSS (n=11), Happiness (n=9), SF-12 physical (n=14), SF-12 mental (n=14), Injury Intent (n=2), ISS (n=3).
Note: Stable housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was their address. Transitional housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was not their address. Unstable housing includes individuals who indicated that they were couch surfing, homeless, or in a shelter.

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