School-Based Hemorrhage Control Training

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Abstract

Preventing deaths from uncontrolled bleeding remains a national priority, as mass causality events in communities and schools continue to rise. National initiatives have been set in motion by the Department of Homeland Security, to teach laypersons hemorrhage control techniques while waiting for emergency personnel to arrive. A full and growing body of evidence supports the use of hemorrhage control training classes among adult laypeople and is growing steadily in the adolescent population. With the majority of shooting events occurring at high schools, the implementation of a hemorrhage control training curriculum can increase survival rates among high school students in the event of an active shooter. The purpose of this paper is to investigate current knowledge and hemorrhage control practices among high school students and the implication of implementing a hemorrhage control educational intervention by evaluating current knowledge of hemorrhage control as well as their willingness, confidence, and perceived value in hemorrhage control education. This evidenced-based assessment is proposed utilizing the Social Learning Theory and Rosswurm and Larrabee's implementation framework.

Keywords: hemorrhage control training, emergency preparedness, program evaluation, school health, empowerment

School-Based Hemorrhage Control Training

The number one cause of preventable death in trauma is uncontrolled bleeding. Even in an era where emergency response times are approximately seven minutes, death from uncontrolled bleeding can occur in as little as five minutes (Jones et al., 2019). Regardless of emergency response times, during disastrous or mass casualty events, bystanders will always be first on scene and are often the first to assist in an emergency (Zhao et al., 2019). With increasing high school shootings nationwide, American adolescents are becoming the first bystanders on scene, indicating a need to incorporate hemorrhage control training in schools.

Problem Statement

Active shooter events are an increasing public health concern affecting our schools, communities, and nation. Since 2018 alone, there have been 324 injuries and fatalities from a total of 250 school shooting incidents in the United States (USDHS, 2020). According to the Centers for Homeland Defense and Security (CHDS), the majority of school shooting incidents happen in high schools, leaving our adolescents at the highest risk for being involved in an active shooter event (CHDS, 2020). Schools have a federal obligation to protect and keep safe the children within their care, to anticipate potential dangers, and take precautions to protect students from such dangers (Alert Lockdown Inform Counter Evacuate [ALICE], 2015). Federally regulated Emergency Operating Procedures (EOPs) now require schools to develop a plan for staff and student response to an active shooter event. Many schools, however, lack proper emergency plans, supplies, and do not incorporate mass-casualty training events or education on hemorrhage control techniques, leaving students more vulnerable and less prepared (ALICE, 2015; Kano et al., 2007).

Purpose and Rationale

The purpose of this project is to distinguish the value and need to implement hemorrhage control techniques into an already established simulated mass casualty event for adolescents during high school. This needs assessment will be the first of its kind and will add to the growing body of literature surrounding hemorrhage control training for the adolescent population. Implementing hemorrhage control training in a high school simulated mass casualty event provides our most at risk population with the knowledge, tools, and empowerment they need to survive, and help others survive, a life-threatening bleeding event (Zhao et al., 2019).

Background and Significance

In the wake of the 2012 Sandy Hook Elementary school shooting, autopsies revealed more lives could have been saved if bleeding control techniques were applied sooner. With uncontrolled bleeding being the number one cause of trauma related death in the world, the need to disseminate hemorrhage control teaching and training to laypeople is evident (ACS, 2020; Stop the Bleed, 2015). The Hartford Consensus, developed through collaboration of the American College of Surgeons (ACS), the United States Department of Homeland Security (USDHS), and other government and nongovernment agencies, determined the need for access to hemorrhage control kits in public areas as well as public access to hemorrhage control training that could be utilized in emergencies (ACS, 2020; Zhao et al., 2019). This report prompted the USDHS in 2015 to implement the national Stop the Bleed (STB) coalition to train laypeople on proper bleeding control techniques and to instill confidence and willingness to react to a bleeding event (Ali et al., 2019; Zhao et al., 2019; Ross et al., 2018).

High School Students

With increasing public active shooter events nationwide, high schools remain at the highest risk for school related active shooter events (Centers for Homeland Security and Defense, 2020).

While schools are charged with protecting and preparing students for many types of emergency situations, many schools continue to fall below federal regulations for preparedness in the event of an active shooter (ALICE, 2015). In response to the increasing number of high school shootings, USDHS worked to institute measures to offer hemorrhage control training specifically to high school students. The USDHS created the School-Age Trauma Training program which aims to create a long-term self-sustaining program among high schools to disseminate lifesaving trauma training for mass casualty events (USDHS, 2018).

Hemorrhage Control Training

Pre-hospital application of a tourniquet to a major wound before arrival to a trauma center has been shown to significantly reduced mortality due to hemorrhagic shock (Scerbo et al., 2017; Kue et al., 2015; Kragh et al., 2008). Many studies have shown that, with STB training, lay people are more confident in their abilities to tourniquet and more willing to tourniquet in an emergency situation (Jones et al., 2019; Lei et al., 2019; McCarty et al., 2019; Tsur et al., 2019; Zhao et al., 2019; Zwislewski et al., 2019; Goralnick et al., 2018; Ross et al., 2018). In person, hands-on STB hemorrhage control training has shown to be the most successful way to deliver this education among lay people (Ali et al., 2019; Goralnick et al., 2018; Zwislewski et al., 2019). In person, hands-on-training has also been shown to improve tourniquet application techniques and showed an increased likelihood of effective tourniquet application post-training (Ali et al., 2019; Zwislewski et al., 2019).

Current Hemorrhage Control Training

While schools are federally obligated to plan and prepare for an active shooter event, there is no current federal guideline supporting the mandatory implementation of hemorrhage control training in high schools (ALICE, 2015; Kano et al., 2007). Although the USDHS has funded a

$1.8 million grant to implement the School-Age Trauma Training program, it is still unclear how the development of this program will translate to high schools nationwide (USDHS, 2020). Currently, most states have implemented legislation requiring cardiopulmonary resuscitation (CPR) before high school graduation. However, CPR training does not currently incorporate lifesaving hemorrhage control techniques with use of conventional and unconventional tourniquet devices.

Self-efficacy and Willingness to Apply Hemorrhage Control Techniques

Many studies have evaluated participant confidence, competence, and willingness to assist in an emergency bleeding event post STB and other nationally recognized hemorrhage control training. Findings from these studies reported increased confidence and competence post in-person hands-on hemorrhage control training (Bondmass, 2019; Goralnick et al., 2018; Lei et al., 2019; McCarty et al., 2019; Ross et al., 2018; Schroll et al., 2020, Tsur et al., 2019; Zwislewski et al., 2019). Along with increased confidence and competence, these studies also reported on retention of tourniquet skills and have found retention of skills is best with hands-on application of techniques. However, studies have also concluded that repeated practice of skills and re-fresher courses increase competence and effective tourniquet application which supports hosting an annual simulated mass casualty event (Baruch et al., 2016; Pasely et al., 2018; Weinman et al., 2019; Zwislewski et al., 2019).

Overall, current evidence and national initiatives support the implementation of hemorrhage control training to the general public, as well as targeted training courses for high school students. Studies on this topic support hands-on, in-person educational training for skill acquisition with re-fresher courses to enhance confidence, competence, and retention of tourniquet application (Ali et al., 2019; Goralnick et al., 2018; McCarty et al., 2019; Tsur et al., 2019;

Weinman et al., 2019; Zwislewski et al., 2019). Hemorrhage control training has the capacity to become the standard of care for schools aiming to improve school compliance with federal guidelines by acknowledging the school's duty to protect students at the district level by developing a comprehensive district wide safety plan.

Internal Evidence

A rural high school located in the Southwestern United States, serving 2,200 students grades nine through 12, currently uses the alert, lockdown, inform, counter, evacuate (ALICE) enhanced school lockdown procedures. The goals of ALICE procedures are to inform, empower, and create awareness with teachers and students in an aim to increase survivability in an active shooter event (ALICE, 2015). Schools have a duty to protect students from injury. ALICE 2015 performed a case study discussing the new federal guidelines, finding many schools missing the mark on meeting these new guidelines and recommendations. If a school is found to have not used an appropriate standard of care, the district could be held liable for negligence (ALICE, 2015).

This high school is currently hosting a mass-casualty event although, only students involved in Junior Reserve Officer's Training Corps (JROTC), sports medicine, and medical professional programs are allowed to participate. Besides not providing for participation or education to students outside these programs, the fundamentals of hemorrhage control are not incorporated in the current mass-casualty event. With the growing frequency of school shootings, schools are in a unique position to disseminate theses teachings to their students, and thereby increase survivability in an active shooter event.

PICOT Question

This inquiry has led to the question: "Among high school students, would receiving hemorrhage control training in a simulated mass casualty event, compared to traditional first aid

training, affect students' report of confidence, performance, knowledge, and willingness to apply hemorrhage control techniques during high school?"

Search Strategy

To address this PICOT question, an exhaustive literature review was conducted among three databases; Cumulative Index to Nursing and Allied Health Literature (CINAHL), PubMed, and the Cochrane Library. The selection of these databases was based on their relevancy to the topic of hemorrhage control as well as their consistency, objectivity, and accuracy of published works supporting the medical professions. Keywords utilized for all three databases were targeted to each component of the PICOT question with the use of Boolean connectors 'OR' to widen search results as the topic of hemorrhage control training to adolescents is relatively new and research is limited. All keywords for each component of the PICOT question where searched collectively and connected with the Boolean phrase 'AND' between each of the components search terms.

Prior to searching each database, filters were set to only include articles that were peer-reviewed, English language, and had a date of publication between January 1, 2015 to January 1, 2020. Search terms utilized for population included: *high school students*, *adolescents, young adults, teens*, *teenagers,* and *high schooler*. Intervention search terms included: *Stop the Bleed*, *tourniquet training*, *tourniquet*, *hemorrhage control*, and *bleeding control.* Comparison search terms were specified to current forms of life saving measures including: *first aid*, *CPR*, *BLS*, and *basic life support*. Outcome search terms included: *knowledge*, *competence*, *confidence*, and *skills*.

The initial PubMed database search utilized all search terms as listed above and resulted 15 articles which then led to a search of similar articles leading to 106 results. Further review of

the 106 similar articles led to two other similar article searches resulting in another 127 and 130 articles. Titles and abstracts from all four of these searches were reviewed, all of which, resulted the same original 15 articles populated from the utilization of all PICOT component search terms. From this search a total of 35 articles were selected for further review.

The initial Cochrane Library search, utilizing all search terms from each component of the PICOT question, resulted in nine Cochrane reviews that matched the defined search criteria. All search terms were utilized to broaden search results as well as elimination of certain PICOT components for new searches that did not yield any new results and resulted in zero matches. Considering the nature of this PICOT question and its relatively newer aim toward hemorrhage control teaching to laypersons, none of the original nine Cochrane results met inclusion criteria.

The initial CINAHL search utilized all search terms from each component of the PICOT question as listed above and resulted in three articles, two of which were selected for review. Different searches were conducted eliminating different components of the PICOT to widen search results, however, when search terms from differing components were eliminated the search resulted in zero articles. All three article abstracts were reviewed and selected for further evaluation.

Of the 38 chosen studies, 26 studies were identified as relevant from the database searches. Reference lists were reviewed for other pertinent studies finding no other relevant studies meeting criteria for this literature review. All 26 relevant studies were further evaluated against inclusion and exclusion criteria. Inclusion criteria were studies targeting laypersons, any method of hemorrhage control training or teaching, and review of skill acquisition or skill retainment. Exclusion criteria included any studies targeting healthcare workers, emergency services personnel, or any population with previous medical training. Once evaluated against

inclusion and exclusion criteria 18 articles remained and a rapid critical appraisal was performed for each, ten of which were chosen for a further in-depth thorough review (Appendix B).

Critical Appraisal and Synthesis

Ten studies were selected for this literature review and were critically appraised utilizing the Melnyk and Fineout-Overholt's (2011) rapid critical appraisal checklist to assess quality and validity. Of the 10 articles, four were randomized control trials (RCTs), four were mixed methods non-randomized non-controlled studies, and two were cross-sectional observational studies (Appendix A). Given the relative novelty of hemorrhage control training to laypersons, no systematic reviews have been conducted, and RCTs were limited due to strict inclusion criteria. The novelty of this evidence is also seen in the year of publication, with more than half of the included studies published in 2019 (Appendix B). No bias was noted in any of the selected articles, only five articles discussed funding, and all but two were conducted in the United States of America.

All studies utilized adult populations, with a mean participant age between 30 and 60 years, rather than the intended adolescent population age. In all but two studies, the participants included were exclusively non-medically trained laypersons, as will be the project's targeted high school population. Overall, a strong degree of homogeneity was seen in sample demographics among all 10 studies, as well as variables of interest. All 10 studies evaluated correct tourniquet placement following an educational intervention, provided hands-on practice, and evaluated participant knowledge of tourniquet application (Appendix B). Measurement tools were consistent across all 10 studies utilizing direct observation for skill attainment, and tourniquet placement via trained study personnel. More than half of the articles also utilized pre and post questionnaires to evaluate participant responses to educational interventions in relation

to increased knowledge, willingness, and comfort in tourniquet application. Primary outcomes across all 10 studies identified correct tourniquet application after an educational intervention, hands-on practice, as well as increased tourniquet knowledge.

Conclusion

Hemorrhage control training among laypersons is a novel approach thought to improve survival among community members should a mass casualty event occur. National initiatives, including the Stop the Bleed campaign, are quickly gaining momentum to help bystanders intervene and stop blood loss before the arrival of emergency services. While this topic is still undergoing research and testing, current evidence is already showing success in laypersons' ability to correctly apply tourniquets after an educational intervention, and hands-on practice. Evidence has also shown an increased willingness, and preparedness to intervene for a stranger after completion of hemorrhage control training. With high schools having the highest rates of active shooter events, this project has the capacity to positively impact high school student survival rates should an active shooter event occur. By implementing a hemorrhage control training intervention, nurse practitioners, pediatric and adult alike, can have a profound impact on the safety, wellbeing, and survival of their community members.

Conceptual Framework and EBP Model

Albert Bandura's Social Learning Theory (SLT) was chosen as the underpinning theory of this project as it clarifies how adolescents learn (Appendix C). SLT fits well into the paradigm of this project and encompasses cognitive, behavioral, and environmental factors of the adolescent learner. Applying SLT to the adolescent learner will promote observing and role modeling positive behaviors, encourage confidence in adolescent's capability of acquiring and practicing new skills, allow learners to gain a positive attitude toward new skills, and increase

self-efficacy in implementing and utilizing newly acquired skills (Butts & Rich, 2018). This project is based on a need's assessment for the implementation of an educational intervention thus, understanding the way adolescents learn will help guide and predict the outcomes and best measures to take during the implementation of the proposed educational intervention.

While the SLT presents a way to understand and predict the cognitive, behavioral, and environmental needs necessary to develop a successful educational intervention, Rosswurm and Larrabee's model guided the application and implementation of evidence for this project (Appendix D). Rosswurm and Larrabee's (1999) model provided a systematic approach for the implementation process of evidenced-based change from assessing the need for change, linking problems to interventions, synthesis of evidence, designing a practice change, implementing and evaluating change, to the integration and maintenance of change (Appendix D). This implementation framework was well suited for this project in its inherent structure and utilization of both quantitative and qualitative data, and contextual evidence which supports the current body of evidence on this topic. Incorporation of both the SLT and the Rosswurm and Larrabee implementation model provided continuity during the translation of evidence to practice process in a systematic well-organized manner.

Applying Evidence to Practice

Implications for this practice change have the potential for a profound effect on the survivability of those involved in a mass casualty or serious bleeding event by implementing an educational hemorrhage control training course. Evidence shows one-day hemorrhage control training sessions have a positive effect on not only skill acquisition of hemorrhage control techniques, but increase knowledge, confidence, and willingness of participants to react during a bleeding event. Stop the Bleed (STB) training is a national initiative from the United States

Department of Homeland Security (DHS). This one-day training course was developed to teach laypeople hemorrhage control techniques until the arrival of emergency personnel. This course focuses on identification of severe bleeding, immediate application of manual pressure, tourniquet application, and wound packing techniques. Currently, STB training consists of a brief slide show presentation, discussion of hemorrhage control techniques, and hands-on practice. Success among adult layperson populations has been seen throughout the literature however, little research on STB training in the adolescent population has been performed to date. With more than half the current evidence utilizing this nationally recognized teaching program, the likelihood of its success in a local high school with an adolescent population remains high.

Methods

Overall Study Design

The overall study design of this evidenced-based needs assessment was completed in five phases. The recruitment phase initially consisted of identification of students participating in HOSA programs and was followed by, phase two, a recruitment speech to students in the HOSA medical professions and sports medicine programs. Determination of eligibility to sit for the student survey and dissemination and collection of parental informed consents marked phase three. Next students and staff completed an online survey which was directed at evaluating values and beliefs towards hemorrhage control training. Finally, data analysis was performed on both the student and faculty surveys.

Ethics

Permission to conduct this evidenced-based needs assessment was granted by expedited review from the Arizona State University Institutional Review Board on October 12, 2020 lasting one year from approval date. To protect participant privacy, no personal identifying

information was collected during the survey dissemination process. All survey responses were collected via QuestionPro software utilizing anonymously generated identification numbers to preserve anonymity of responses. All participating faculty, staff, and students 18 years of age and older were required to consent electronically prior to the start of the survey. All minor students, ages 14-17, were required to provide written parental consent along with school issued identification badge to verify written consent matched the student present prior to admittance to sit and take the survey. All minor students were also required to electronically assent to the survey prior to survey start. Students' faculty remained present throughout the entirety of the intervention process.

Recruitment

Upon receiving IRB approval, recruitment initially consisted of identification of students participating in HOSA programs, as these students have an expressed interest in healthcare directed programs. Due to faculty turnover midsemester, students in the HOSA JROTC program were unable to participate in this intervention and recruitment was limited to the medical professions and sports medicine programs. Recruitment was performed via speech to students utilizing a Zoom session during class time. Between these two programs, 133 students were recruited by a short speech discussing project specifics and goals. Recruitment for all 93 faculty members was performed via email. Inclusion criteria for students in this project consisted of enrollment in either the medical professions or sports medicine program at the project site and furnishing a signed parental consent with school issued identification for all minors aged 14-17 years. Inclusion criteria for faculty consisted of being 18 years or older and employed at project site. Exclusion criteria for students included not being enrolled in either the medical professions

or sports medicine program and no signed parental consent for minor students. Exclusion criteria for faculty included any faculty member who was not directly employed at the project site.

Setting

This evidence-based project took place at a local high school in a rural community in the Southwestern US. This high school is currently hosting an annual mass casualty (MASCAL) event with participation from both the medical professions and sports medicine programs. These students were targeted in their ability to utilize hemorrhage control training in this annual event. All 100 students currently enrolled in the sports medicine program and the 33 medical professions students were invited to participate in this needs assessment.

Intervention

Layperson hemorrhage control training has shown to be a successful grassroots effort to improve survivability of a serious bleeding event. The project aimed to utilize surveys to understand faculty and students' attitudes, values, and beliefs toward hemorrhage control training as well as faculty perceived preparedness for a serious bleeding event. This evidenced-based needs assessment took place over a 4-week period in which the faculty survey was sent via email to all faculty members and remained open for one week before closing in which 49 (53%) faculty members participated. The student survey took place during a one-day session in an on-campus computer lab with site champion and student faculty present where 80 (60%) students participated.

Measures

The primary outcome variable for this project included understanding student and faculty perceived attitudes, values, and beliefs, toward receiving hemorrhage control training. This data was gathered using two originally created surveys due to the lack of hemorrhage control self-

efficacy measurement tools. The student survey created was five questions, three dichotomous and two five-point Likert scale, to evaluate student willingness to participate in and utilize hemorrhage control training as well as understand their perceived value toward hemorrhage control training. The faculty survey created was seven questions, five dichotomous and two five-point Likert scale, to evaluate perceived school preparedness, value of hemorrhage control training, and likelihood of utilizing the training if needed. Both surveys are non-standardized measures that have not been tested for validity or reliability but were created from previous research and theory utilizing combination dichotomous and Likert style questions to evaluate willingness, value, and comfort level (Ali et al., 2019; Ross et al., 2018).

Data Analysis

The primary analysis for the student and faculty survey was to understand perceived value, willingness, and desire to receive hemorrhage control training. Secondarily, faculty perceived school preparedness to respond to a serious bleeding was also evaluated to better understand and quantify the need for hemorrhage control training implementation. Statistical data was collected via QuestionPro software and exported to Intellectus software where it was stored and analyzed using descriptive statistics to describe the outcome variable.

Results

Statistical analysis was conducted utilizing descriptive statistics to determine student and faculty perceived value, willingness, and need for hemorrhage control training. The results of the student survey (Figure C1) found 96% of students believe hemorrhage control training would be beneficial, 81% feel unprepared to handle a serious bleeding event, 85% want training. However, only 38% said they would be very likely to utilize received training. These results suggest students do want and value hemorrhage control training and do feel unprepared to handle a

serious bleeding event. While only 38% of students reported feeling very likely to utilize hemorrhage control training, this may be, in part, due to a lack of understanding of what skills they would be deploying and perceived self-efficacy of skill utilization after educational intervention.

The results of the faculty survey (Figure C2) found only 20% of faculty have received hemorrhage control training, only 2.4% were aware that their school offered hemorrhage control training to faculty, 54% felt the school was unprepared to handle a serious bleeding event and 44% reported feeling very likely to assist with a serious bleeding event with the proper training. The faculty survey also suggests that while only 2.4% of faculty have received hemorrhage control training, 63% currently feel comfortable providing interventions for a serious bleeding event.

Discussion

Evidence strongly supports the implementation of hemorrhage control training among laypersons and implementing training programs that specifically target adolescents are essential as the majority of school shooting events occur in high schools. The findings from this needs assessment strongly depicts the desire and value seen in hemorrhage control training by students and faculty. The findings from both surveys also suggest an overall feeling of unpreparedness personally and in relation to the school's ability to appropriately handle and respond to a life-threatening bleeding event. Layperson hemorrhage control training can provide students and faculty with not only the skills to stop a serious bleed but also the confidence to utilize learned skills and techniques.

Limitations

Limitations of this project consist of the use of originally made self-report surveys and inability to perform hands-on in-person training due to the COVID-19 pandemic. Additionally, the student survey was only open to HOSA students who already have a direct interest in healthcare and did not capture the attitudes, values, and beliefs of the general student population.

Future Implications

Future studies targeting the adolescent population with more representative student populations are required to broaden and support the growing body of evidence surrounding hemorrhage control training for high school adolescents. Future research should include implementing hands-on in-person training with pre- and post-surveys to evaluate self-efficacy of learned skills and skill acquisition. Additionally, future studies should also examine the adolescent learner's ability to retain learned skills by providing a post evaluation sometime after initial implementation.

Conclusion

Layperson hemorrhage control training is a novel approach aimed to improve survival from life-threatening bleeding events. The aim of this evaluation assessment was to better understand student and faculty values and beliefs toward receiving hemorrhage control training to support and direct future implementation of a hemorrhage control educational intervention. Current evidence surrounding layperson hemorrhage control training strongly supports its value and effectiveness among adult learners. This project adds insight into adolescent attitudes, values, and beliefs towards hemorrhage control training for this growing body of evidence. Implementation of hemorrhage control training among high school students has the potential to increase the likelihood of student survival should an active shooter or serious bleeding event occur. Another potential outcome of this project is the transference of learned lifesaving skills to

other everyday scenarios such as accidental injuries, falls, and vehicle collisions. Effectively delivering hemorrhage control training to high school adolescents has the potential to give our most at-risk population the greatest chance for survival.

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Appendix A

Evaluation and Synthesis Tables

Table A1

Evaluation Table Quantitative Studies

Citation	Theory/ Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables & Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Results	Level/Quality of Evidence; Decision for practice/ application to practice
Ali et al., 2019 Teaching how to stop the bleed: Does it work? A prospective evaluation of tourniquet application in law enforcement officers and private security personnel. **Country:** U.S.A. **Funding:** Not disclosed.	Adult Learning Theory	**Design:** Mixed methods NRNCT (pre-&post-test) **Purpose:** To assess correct tourniquet knowledge and comfort level of tourniquet application after 7 didactic and practical sessions.	**N:** 151 **Site:** Recreational site in community. **Demographics:** 118 (78%) male, 28 (18.5%) female, 5 (3.5%) other-no answer provided **Inclusion:** Police officers and security personnel from secondary schools, universities, hospitals, and	**IV:** Correct tourniquet placement in a simulated scenario **DV1:** Correct tourniquet placement **DV2:** Time to tourniquet application **DV3:** Increased Comfort applying tourniquet **DV4:** Familiarity with anatomy and bleeding control	DO of skills DV1, DV2 Self-assessment, DV3, DV4	Likert Scale for pre/post questionnaire Fisher's exact tests or Wilcoxon matched-pairs signed-ranked tests to compare pre-post measurements	**DV1:** Pre-17.2% (26/151); post-92.7% (140/151) **DV2:** Mean times were pre 29.8 ±18.5 to post 18.7 ± 6.7 ($p<0.001$) **DV3:** 5.1 ± 3.3 to 8.8 ± 2.2, ($p<0.001$) **DV4:** 9.2 ± 1.9 (95% CI 8.9-9.5)	**LOE:** III **Strengths:** Mixed methodology supports a well-rounded view of B-Con intervention. Appropriate analysis for quantitative and qualitative data. Study subjects had no previous tourniquet knowledge, quantified by Likert results. Structured course based on STB guidelines. **Weaknesses:** Level III evidence. Small study group. Some participants were allowed to practice multiple times. Only evaluation of skills

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Citation	Theory/ Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables & Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Results	Level/Quality of Evidence; Decision for practice/ application to practice
Bias: None noted.			commercial businesses. **Attrition:** No participants lost.					was immediately post training. Did not focus on civilian population, may not be generalizable to general population. **Conclusions:** STB course has immediate and reproducible on tourniquet application and skill acquisition.
Baruch et al., 2016 Does practice make perfect? Prospectively comparing effects of 2 amounts of practice on tourniquet use performance **Country:** Israel **Funding:** No funding from commercial, not-for-	Inferred Adult Learning Model	**Design:** Prospective Educational study. Mixed methods NRNCT (pre-&post-test). **Purpose:** To compare to amounts of practice of tourniquet training.	**N: 156** **n:** 87 (TAP) **n:** 69 (SAP) **Site:** Israeli military platoon. **Demographics:** All new male recruits age 18-20, median age 18, from a single infantry brigade enlisted for active duty. **Inclusion:** Had to be a qualified "Life Saver", 42 recruits were excluded because they	**IV:** Effective application of tourniquet after either SAP or TAP. **DV1:** Participants able to apply pressure **DV2:** Participants application time. **DV3:** Participants unable to apply pressure.	Direct observation and evaluation of no distal pulse from tourniquet site.	Intragroup comparisons of continuous data, a paired t test was used. A $\chi 2$ test was used for categorical data. The Student t test was performed, all t tests were 2 tailed. A Cochran-Mantel-Haenszel test was used between groups and	**DV1:** No significant difference (P =0.6) between SAP and TAP groups ability to apply pressure. **DV2:** Significant difference was seen in TAP participants application time (p <0.001).	**LOE:** III **Strengths:** Appropriate analysis for quantitative data. Participants had not previous tourniquet training. Study was conducted in the field under real combat situations. **Weaknesses:** Population not generalizable. High dropout rate. Lower level of evidence. Not generalizable to the general public. **Conclusion:** The TAP was more effective

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profit, or private section utilized. **Bias:** None declared.			were not qualified "Life Savers. **Attrition:** 108 dropped out of the study during initial assessment and 43 were not available for final assessment.			across assessments for those unable to apply pressure. Significance set as $P \leq .05$ for all tests.	**DV3:** TAP group improved more than the SAP group in their ability to improve those who could not apply any pressure 18% reduction verses an 8% reduction; P = .009	than SAP, this knowledge can be applied to other organizations and B-Con classes.
Goolsby et al., 2016 Analysis of layperson tourniquet application using a novel color-coded device **Country:** U.S.A.	Inferred Trial Design Model	**Design:** Prospective RCT **Purpose:** to evaluate the lay person ability to use a color-coded tourniquet designed for lay person	**N:** 157 **n:** 72 (Color-Coded) **n:** 85 (All black) **Site:** University in midwestern U.S.A. **Demographics:** Color-coded 31% male, All black 38% male.	**IV:** Correct application of the tourniquet **DV1:** Color-coded tourniquet **DV2:** All black tourniquet	Direct observation of tourniquet application by medically trained staff.	Chi-squared or Fisher's exact tests for proportions. Mann-Whitney testing was done for comfort level and time to successful application.	**DV1:** 51.38% (n = 37) applied the device correctly. **DV2:** 44.71% (n = 38) applied the device correctly.	**LOE:** II **Strengths:** RCT level design, inherently high-level evidence. Statistical analysis used was appropriate for this study. Findings of this study are generalizable to the general population. **Weaknesses:** Occurred in a controlled

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Citation	Theory/ Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables & Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Results	Level/Quality of Evidence; Decision for practice/ application to practice
Funding: Funded by the USU Office of Research and the Office of the Dean through the Capstone Student Research Program **Bias:** None noted.		rather than a combat application tourniquet.	Mean age 35.5 color-coded, 32.5 all black. **Exclusion:** Less than 18, having military experience in that last 15 years, prior tourniquet training, being a licensed healthcare provider, or medical training beyond high school CPR. **Attrition:** None lost.				6.67% difference between tourniquets not statistically significant, (risk ratio [RR]: 1.15; 95% confidence interval [CI]: 0.83-1.59; P = 0.404, chi-square test).	environment. Soliciting with poster could induce a selection bias. Small population. Only assessed laypeople ability to apply tourniquet but not when to actually use one. **Conclusions:** Laypeople are capable of applying tourniquets successfully. Their application time is likely fast enough to save lives.
Goralnick et al., 2018 Effectiveness of instructional interventions for hemorrhage control	Inferred Trial Design Model	**Design:** RCT **Purpose:** To determine the effectiveness of different	**N:** 464 laypersons **n:** 232 (CG) **n:** 232 (IG) Participants divided equally among the study arms.	**IV:** Correct tourniquet application in a simulated scenario **DV1:** Instructional Flash cards	Observer recorded whether or not tourniquet was applied properly in simulated scenario.	Wilcoxon rank sum test to compare time with correct tourniquet placement across arms.	**DV3:** highest proportion of correct tourniquet applications (87.7%; 95% CI, 81.8-93.6) compared	**LOE:** Level II **Strengths:** RCT level design. Detailed discussion of interventions. Findings of this study are generalizable to the general population.

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readiness for laypersons in the public access and tourniquet training study (PATTS): A randomized clinical trial. **Country:** U.S.A. **Funding:** Partially supported by the Gillian Reny Stepping Strong Center for Trauma Innovation. **Bias:** None noted.		instructional interventions and in-person HC training compared to no intervention and assess skill retention 3-9 months after training.	**Site:** Sports stadium in Massachusetts **Demographics:** Of the 464 participants 189 were female leaving a higher proportion of men. Highest level of education: 111 (21.7%) reported high school or less; 189 (40.7%) had some college; 128 (27.5%) had a bachelor's degree; 36 (7.7%) had an advanced degree. **Exclusion:** Anyone with previous hemorrhage control training **Attrition:** Of the 464	**DV2:** audio kits with embedded flashcards **DV3:** B-con course	Observers were medically trained professionals.	2-sided Fisher exact tests for categorical variables with logistic regression analysis to identify any demographic associations with correct tourniquet placement.	with control group (16.3%; 95%CI, 9.1-23.6; P<.001). No difference in successful tourniquet placement between DV1 or DV2 compared to control arm. **DV1:** 19.7%; 95% CI, 12.3-27.0 **DV2:** 23.0%; 95% CI; 15.4-30.5) compared with control arm (16.3%;95 % CI; 9.1-	**Weaknesses:** B-con technique is hard to evaluate in a simulation setting. Scenario does not mimic stress and chaos of a true emergency. Evaluators were not blinded, although given the wide range of differences seen potential for bias is minimal. 35% of the sample was lost to follow-up. **Conclusions:** B-con in person training is the superior to audio kits, flashcards, and no prior training. B-con is an effective way to train bystanders thus supporting the call to train laypeople in bleeding control programs.

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			participants 303 (65%) were assessed for retention. At retention testing, no statistically significant (P>0.05) between demographics of those in control group and those who were reassessed.				23.6; P>.05)	
Jones et al., 2019 Evaluation of "stop the bleed" training among k-12 faculty and staff in Alabama **Country:** U.SA. **Funding:** Funding through the Community		**Design:** Cross-sectional observational study with a convenience, non-probability sampling technique **Purpose:** To evaluate STB training among K12 personnel	**N:** 466 full-time personnel utilizing convivence, non-probability sampling technique **Site:** Public city school system in Alabama. **Demographics:** Largely Caucasian (67%) females (80%) between	**IV:** To assess perceived readiness and willingness to train other faculty members STB methods. **DV:** Trauma outreach personnel completed STB training with faculty and staff.	Data was collected using an anonymous online survey.	5-point Likert Scale with logistic regression to evaluate association among post training feelings and perceived preparedness to train others in STB. Wilcoxon signed rank test prior to and after	136 survey responses received with a response rate of 29%. After HC training: reports of increased knowledge of HC methods/techniques P <.001; increased comfort	**LOE:** V **Strengths:** This study found great implications for implementation at other schools. The findings are logical and were not surprising. This study confirms the use of STB training with laypersons is effective. **Weaknesses:** Being the lowest level of evidence is inherently a weakness. The

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Health Scholars Program at the University of Alabama at Birmingham School of Public Health. **Bias:** None noted.		and to assess participants ' perceived readiness to train peers in STB methods.	the ages of 18-85. **Exclusion:** Had to be at least 18 years old, speak English, and held full time positions at the school system. **Attrition:** Not discussed.			completing training.	with providing HC to injured persons P <.001; empowered to organize STB training their home institution p < .001 72% (n=91) of participants reported the HC training they received adequately prepared them to tech others. Logistic regression results found participants eight times more likely	population is not generalizable. Convenience sample utilized. No simulated events were utilized to demonstrate effective application of HC measures. **Conclusions:** After a single STB training course faculty felt comfortable and willing to apply HC techniques to injured persons. This study confirms the success of this course in other schools is likely.

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							than their peer to teach others STB techniques [OR] 7.65, 95% [CI] 2.41-24.25.	
Lei et al., 2018 Stop the bleed training empowers learners to act to prevent unnecessary hemorrhagic death **Country:** U.S.A. **Funding:** Projected funded by the Center for Translational Injury Research **Bias:** None noted.	Inferred Adult Learning Theory	**Design:** Mixed methods NRNCT (pre-&post-test) **Purpose:** Develop and test an educational B-con program for increased willingness, preparedness, and knowledge.	**N:** 555 **Site:** Medical School **Demographics:** 287 SN, 123 MS3, 68 ID, 77 CM **Exclusion:** Incomplete surveys (19), lack of anonymous identifier (30), and those who choose to opt out (0). **Attrition:** No participants lost.	**IV:** Increase willingness and preparedness to intervene and preform tourniquet application. **DV1:** Increase willingness **DV2:** Increase preparedness **DV3:** Correct knowledge about tourniquet placement and HC.	Self-assessment of DV1, DV2, & DV3.	Likert Scale for pre/post questionnaire**;** pre α 0.38, post α 0.72. Pre/post-training data was analyzed using T-test and Wilcoxon-signed ranked test, with significance defined as $p < 0.05$	**DV1:** pre: SN 92%, MS3 93%, ID 88% CM 96% Post: SN 99%, MS3 99%, ID 99%, CM 99% **DV2:** Pre: SN 80% MS3 19% ID 34% CM 48% responded positively ($p < 0.05$). Post: SN 100%, MS3 98%, ID 99%, CM 99% **DV3:**	**LOE:** III **Strengths:** Mixed methodology supports a well-rounded view of B-Con intervention. Appropriate analysis for quantitative and qualitative data. Intervention was well described. This study had an adequate population size. Population was diverse making the result generalizable to the general population. **Weaknesses:** Lower level of evidence. This study is limited by lack of long-term follow-up with the participants as well as training on real life bleeding situations.

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							Passing set at >60% Pre: SN 63% MS3 76% ID 66% CM 48% Post: SN 89% MS3 100% ID 85% CM 86%	**Conclusion:** B-Con training is effective at increasing participants preparedness and willingness to intervene during a bleeding event with a stranger.
McCarty et al. 2019 Effectiveness of the American College of Surgeons bleeding control basic training among laypeople applying different tourniquet types: A	Inferred Adult Learning Theory	**Design:** RCT non-blinded, crossover **Purpose:** To evaluate the effectiveness of laypersons ability to apply a tourniquet other than the one they were	**N:** 102 **Site:** Sports stadium **Demographics:** 50 [49.0%] male, Median [interquartile range] age, 37.5 [27.0-53.0] years **Exclusion:** Persons with previous	**IV:** Correct tourniquet application defined by ≥250 mm Hg with a 2-minute time cap, after an educational intervention during a simulated event utilizing three different tourniquets **DV1:** CAT **DV2:** SOFTT	Direct observation by trained personnel.	Correct CAT application was used as an internal control utilizing 4 pairwise Bonferroni-corrected comparisons with the McNemar test.	**DV1:** CAT was applied correctly at a significantly higher rate 92.2% of participants **DV2:** 68.6% applied this tourniquet correctly **DV3:** 11.8%	**LOE: II** **Strengths:** RCT level design. One of the fist studies to evaluate laypersons ability to apply tourniquet other than the one they were trained on. Detailed discussion of interventions. Findings of this study are generalizable to the general population. **Weaknesses:** This was a non-randomized non-controlled trial

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randomized clinical trial **Country:** U.S.A. **Funding:** Not disclosed. **Bias:** None noted.		trained on in a B-Con course.	medical training. **Attrition:** One-day course no participants lost.	**DV3:** Stretch-Wrap-and-Tuck Tourniquet **DV4:** Rapid Application Tourniquet System **DV5:** improvised tourniquet			applied tourniquet correctly **DV3:** 11.8% applied tourniquet correctly **DV4:** 32.4% applied correctly P<0.001 for each pairwise comparison	although it likely had little impact on the overall results. The educational level of the population was not discussed in the demographics. Evaluation staff was not well discussed in there won training and ability to assess laypersons applications. **Conclusions:** This study found there is a disconnect between B-Con course and the layperson ability to apply a tourniquet other than one traditionally used in B-Con training. Laypersons may not be prepared to assist in bleeding emergencies as tourniquet designs evolve and change.
Ross et al., 2018 Stop the Bleed: The effect of	Inferred Adult Learning Theory	**Design:** Cross-sectional observational study with a	**N:** 218 **Site:** A university in western USA	**IV:** To evaluate perceived readiness and willingness of laypersons to intervene in a	Self-assessment of DV1, DV2, & direct observation of DV3.	Likert Scale for pre/post questionnaire**,** significance p<0.05 and CI 95%	**DV1:** 72.5% (158/218) felt they were safe, 2.3%	**LOE:** III **Strengths:** One of the first to examine barriers to B-Con training. Mixed

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hemorrhage control education on laypersons' willingness to respond during a traumatic medical emergency **Country:** U.S.A **Funding:** Not disclosed. **Bias:** None noted.		convenienc e, non-probability sampling technique **Purpose:** The purpose of this article was to create and educational program to evaluate the type and duration of instruction needed to meet STB requiremen ts.	**Demographics:** All volunteers 31.9% Male (69) 68.1% Female (147); 30.0% (65) College, 2.8% (6) Grade School, 10.1% (22) high school, 8.3% (18) post Grad, 48.8% (106) some college. **Inclusion:** 18 people were excluded because they had previous medical training. **Attrition:** 14 participants did not fill out a post-course questionnaire.	bleeding event after an educational intervention. **DV1:** Participants belief of tourniquets being safe **DV2:** Participants willingness to use a tourniquet in real life after training session **DV3:** Correct tourniquet placement after learning intervention		Fisher's exact tests and Wilcoxon signed-ranked paired tests to compare pre-post measurements McNemar-Bowker test of symmetry utilized for DV1 and DV2.	(5/218) felt they were unsafe, post training 97.5% (199/204) felt they were safe, 0.5% (1/218) still felt they were unsafe. **DV2:** Pre-interventio n 64.2% (140/218) responded "Yes", post-interventio n 95.6% (19/203) responded "Yes". **DV3:** pre-training knowledge 4.1/5 increased to 4.7/5	methodology supports a well-rounded view of B-Con intervention. Appropriate analysis for quantitative and qualitative data. Study subjects had no previous tourniquet knowledge, making this generalizable to the general population. **Weaknesses:** This study was part of a larger study looking at different commercial tourniquets. High-school and middle school students who attended the classes were excluded from the results. This was a convenience sample gathered from one community that volunteered to take B-Con classes. **Conclusion:** This study was able to demonstrate a short educational

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Citation	Theory/ Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables & Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Results	Level/Quality of Evidence; Decision for practice/ application to practice
							(p<0.001) post-training. Correct tourniquet placement pre-training 3.1/4 and 3.6/4 (p,0.001) post-training.	intervention was able to increase laypersons self-efficacy and their reported willingness to intervene in a bleeding event.
Tsur et al., 2019 High tourniquet failure rates among non-medical personnel do not improve with tourniquet training, including combat stress inoculation: A randomized controlled trial.	Trial Design Model	**Design:** Single-Center, parallel-group, randomized control open trial of an educational interventio n. **Purpose:** To examine if early advanced training under condition similar to combat and	**N:** 305 n: 138 (CG) n: 167 (IG) **Site:** Israel Defense Forces' Armored School **Exclusion:** No previous experience with the tourniquets used in this trial. **Demographics:** Males between the ages of 18-20 enlisted to active military	**IV:** Improved competency and correct tourniquet placement in a combat stress inoculation setting. **DV1:** Application of the tourniquet 12 times on themselves or on peers **DV2:** Application of the tourniquet 12 times on themselves or on	Observers, who were similarly qualified instructors, evaluated correct placement by determining lack of distal pulse as palpated by the instructor.	Comparison of categorical variables utilized Chi-square. Quantitative variables compared utilizing student T-test.	Overall failure rate was 80.33% (81.90% in the control group versus 79.00% in the CSI group; P value = .565; 95% CI, 0.677 to 2.122) Differences between time to stop bleeding, or placement	**LOE:** Level II **Strengths:** RCT level design. Detailed discussion of interventions and results. Data collection techniques were appropriate. **Weaknesses:** Not generalizable to general population. Participants, assessors, and instructors were not blinded due to the nature of the educational intervention. Another weakness is the platoon-based randomization.

Key: **B-con**- bleeding control; **CG**- control group; **CM**-community member; **DO**-direct observation; **DV**-dependent variable; **HC**- hemorrhage control; **ID**-interdisciplinary member; **IG**- intervention group; **IV**- independent variable; **MS3**-third year medical student; **N**-number of studies (if SR) or participants in study; **n**- number of participants (if SR) of number of participants in subset; **LOE**- level of evidence; **NRNCT**- nonrandomized noncontrolled trial; **RCT**-randomized control trial; **SAP**-single-application practice; **SOFTT**- Special Operation Forces Tactical Tourniquet; **SN**- school nurses; **STB**- stop the bleed; **TAP**-triple-application practice; **α**-Cronbach's alpha

Citation	Theory/ Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables & Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Results	Level/Quality of Evidence; Decision for practice/ application to practice
Country: Israel **Funding:** None recognized. **Bias:** None noted.		provide stress inoculation improve competenc y compared to the current educational program on non-medical personnel.	duty in August 2017. **Attrition:** Not discussed	peers in combat stress situations including low-light conditions, post-physical-exertion.			were not significant (95% confidence intervals, −17.283 to 23.404, −1.792 to 6.105, and 0.932 to 2.387. The difference in the rate of those unable to apply any pressure between the CSI group and the control group was not significant (18.6% versus 20.3%, 95% confidence interval, 0.507 to 1.583)	

Key: **B-con**- bleeding control; **CG**- control group; **CM**-community member; **DO-**direct observation; **DV**-dependent variable; **HC**- hemorrhage control; **ID**-interdisciplinary member; **IG**- intervention group; **IV**- independent variable; **MS3**-third year medical student; **N**-number of studies (if SR) or participants in study; **n**- number of participants (if SR) of number of participants in subset; **LOE**- level of evidence; **NRNCT**- nonrandomized noncontrolled trial; **RCT**-randomized control trial; **SAP**-single-application practice; **SOFTT**- Special Operation Forces Tactical Tourniquet; **SN**- school nurses; **STB**- stop the bleed; **TAP**-triple-application practice; **α-**Cronbach's alpha

Citation	Theory/ Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables & Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Results	Level/Quality of Evidence; Decision for practice/ application to practice
Zwislewski et al., 2019 Practice makes perfect: The impact of stop the bleed training on hemorrhage control knowledge, wound packing, and tourniquet application in the workplace. **Country:** U.S.A. **Funding:** Not disclosed. **Bias:** None noted.	Inferred Adult Learning Theory	**Design:** Mixed methods NRNCT (pre-&post-test) **Purpose:** To evaluate the effectiveness of various components of the STB program.	**N:** 298 laypersons Wound packing **n:** 94 (IG) **n:** 69 (CG) Tourniquet Application **n:** 70 (IG) **n:** 72 (CG) **Site:** Local Department of Transportation warehouses. **Exclusion:** Participants who did not complete the cognitive pre/post as instructed were removed from this study (n=16) **Demographics:** Not discussed. **Attrition:** Not all participants	**IV:** Laypersons pre/post knowledge of B-Con techniques. **DV1:** Bleeding control knowledge **DV2:** Ability to pack a wound **DV3:** Ability to apply a tourniquet	Self-assessment of DV1. Direct observation for DV2 & DV3 by qualified STB instructors.	Independent sample t-tests and Wilcoxon signed-ranked paired tests to compare pre-post measurements	**DV1:** Scores were higher on the posttest compared to the pretest ($M = 4.63$, $SD = 1.32$) than on the cognitive pre-test ($M = 3.21$, $SD = 1.14$ **DV2:** IG scored significantly higher ($M = 2.93$, $SD = .26$) than the CG ($M = 1.97$, $SD = .77$) $t(161) = 11.21$, $p \leq 0.0001$. **DV3:** Scores were significantl	**LOE:** IV **Strengths:** Mixed methodology supports a well-rounded view of B-Con intervention. Appropriate analysis for quantitative and qualitative data. **Weaknesses:** Lower level of evidence. No demographics collected, although, it was a predominately male population. Not all participants choose to participate in the hands-on training or complete the cognitive post-test which lead to attrition. Limited participant stock in completing the assessments. Warehouse setting not ideal for training due to acoustic issues. **Conclusion:** STB training does increase layperson knowledge of hemorrhage control

Key: **B-con**- bleeding control; **CG**- control group; **CM**-community member; **DO**-direct observation; **DV**-dependent variable; **HC**- hemorrhage control; **ID**-interdisciplinary member; **IG**- intervention group; **IV**- independent variable; **MS3**-third year medical student; **N**-number of studies (if SR) or participants in study; **n**- number of participants (if SR) of number of participants in subset; **LOE**- level of evidence; **NRNCT**- nonrandomized noncontrolled trial; **RCT**-randomized control trial; **SAP**-single-application practice; **SOFTT**- Special Operation Forces Tactical Tourniquet; **SN**- school nurses; **STB**- stop the bleed; **TAP**-triple-application practice; **α**-Cronbach's alpha

Citation	Theory/ Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables & Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Results	Level/Quality of Evidence; Decision for practice/ application to practice
			agreed to complete the cognitive posttest.				y higher in the IG ($M = 7.41$, $SD = .91$) compared to the CG ($M = 5.99$, $SD = 1.81$) $t\,(140) = 5.9$ $p \leq 0.0001$	techniques and hands-on training allows for better performance of hands-on wound packing and tourniquet application skills.

Key: **B-con**- bleeding control; **CG**- control group; **CM**-community member; **DO-**direct observation; **DV**-dependent variable; **HC**- hemorrhage control; **ID**-interdisciplinary member; **IG**- intervention group; **IV**- independent variable; **MS3**-third year medical student; **N**-number of studies (if SR) or participants in study; **n**- number of participants (if SR) of number of participants in subset; **LOE**- level of evidence; **NRNCT**- nonrandomized noncontrolled trial; **RCT**-randomized control trial; **SAP**-single-application practice; **SOFTT**- Special Operation Forces Tactical Tourniquet; **SN**- school nurses; **STB**- stop the bleed; **TAP**-triple-application practice; **α-**Cronbach's alpha

Table A2

Synthesis Table

	Ali et al. 2019	**Baruch et al. 2016**	**Goolsby et al. 2016**	**Goralnick et al. 2018**	**Jones et al. 2019**	**Lei et al. 2019**	**McCarty et al. 2019**	**Ross et al. 2018**	**Tsur et al. 2019**	**Zwislewski et al. 2019**
Design	MM NRNCT	MM NRNCT	RCT	RCT	CSS	MM NRNCT	RCT	CSS	RCT	MM NRNCT
Number of Participants	151	156	157	464	466	555	102	218	205	298
LOE	III	III	II	II	V	III	II	III	II	III
Non-medically trained participants			X	X	X	X	X	X	X	X
Independent Variables										
Correct tourniquet placement	X	X	X	X	X	X	X	X	X	X
Willingness to apply tourniquet					X	X		X		
Dependent Variables										
Correct tourniquet placement with hands-on training	X	X	X	X	X	X	X	X	X	X
Correct tourniquet placement after learning intervention	X	X	X	X	X	X	X	X	X	X
Time to tourniquet application	X	X					X		X	
Increased comfort/willingness applying tourniquet	X				X	X		X		

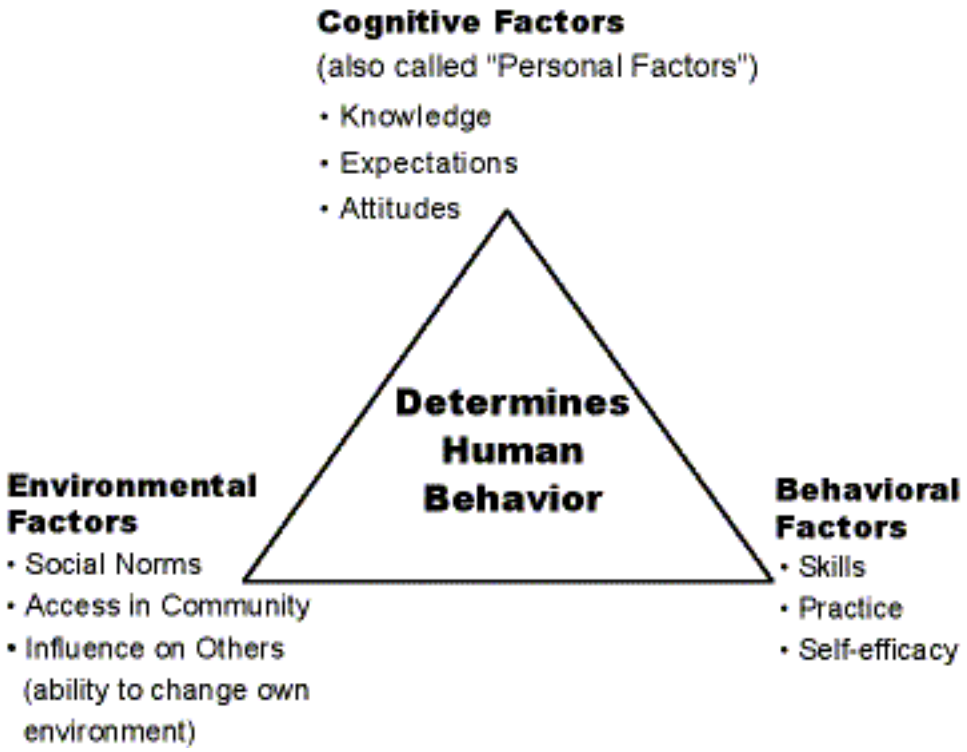
Key: **CSS**-Cross-sectional Study-Observational; **MM**-Mixed Methods; **LOE**- level of evidence; **NRNCT**- nonrandomized noncontrolled trial; **RCT**-randomized control trial

Appendix B

Models and Frameworks

Figure 1

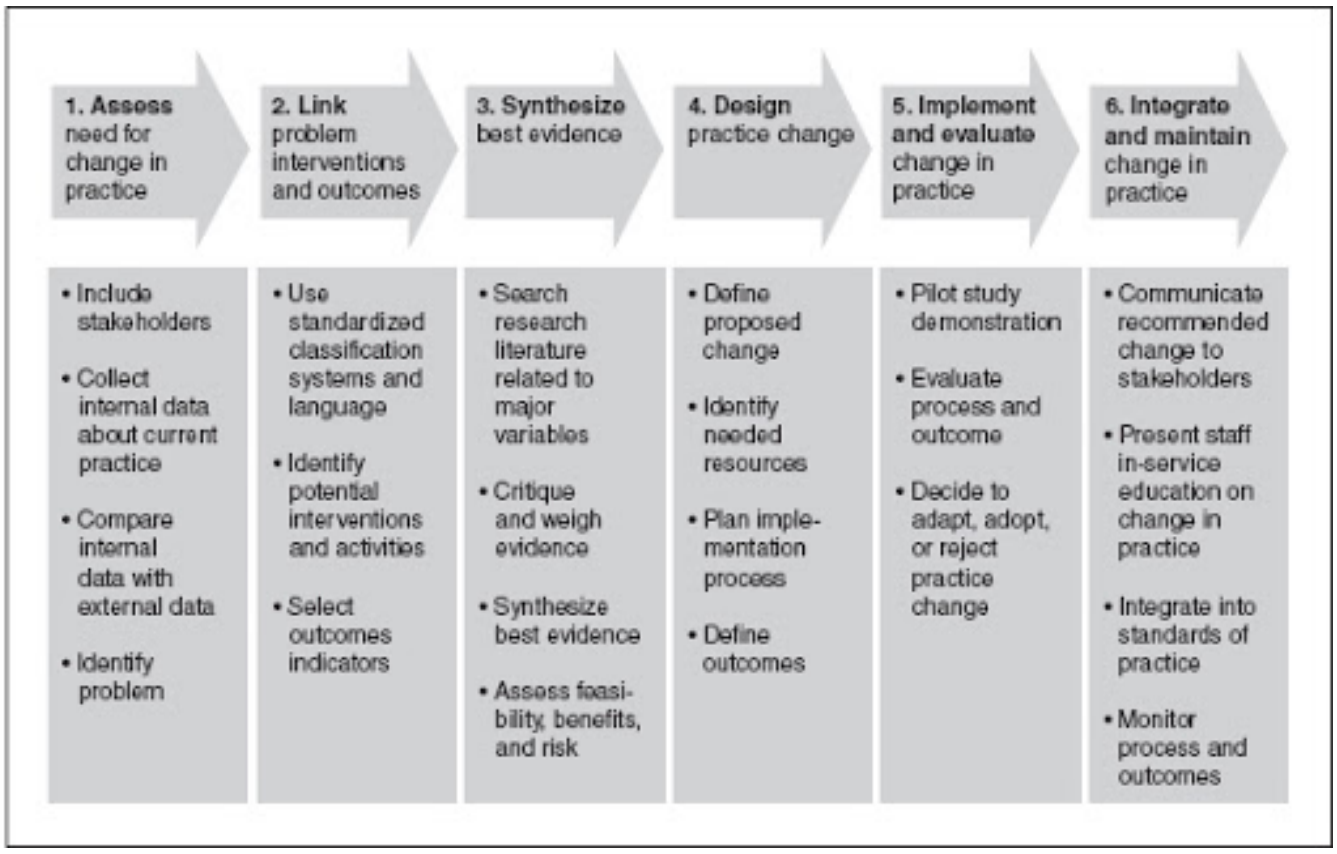
Albert Bandura's Social Learning Theory



Bandura (1986).

Figure 2

Rosswurm & Larrabee's Model



Rosswurm & Larrabee (1999).

Appendix C

Graphical Data

Figure 1

Student Survey Results

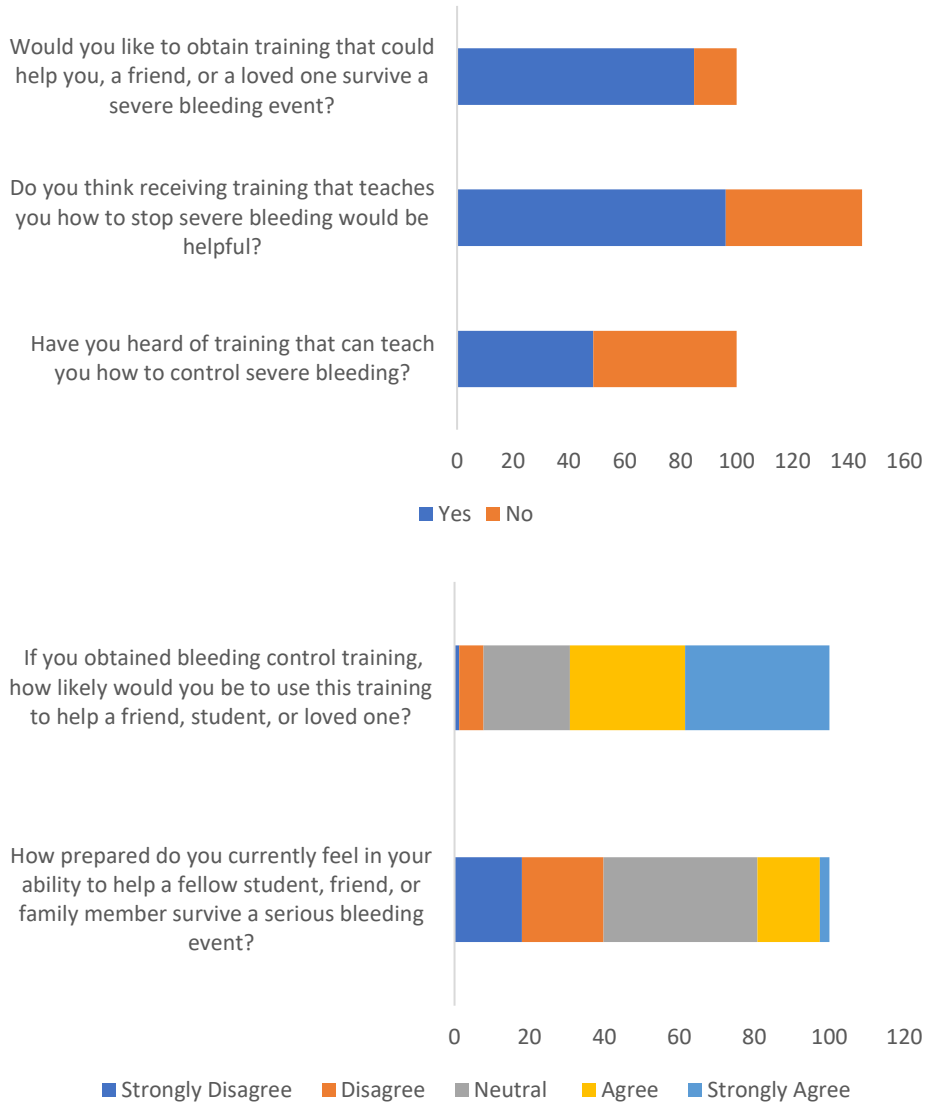


Figure 2

Faculty Survey Results