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Recommendations for Improving Stop the Bleed: A Systematic Review

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ABSTRACT

Introduction:

In response to mass casualty events, The Hartford Consensus brought together subject matter experts across multiple disciplines in health care and public safety to create guidelines and publications intended to improve survivability in active shooter events. Among the recommendations was the earlier recognition and treatment application of life-threatening hemorrhage control. These recommendations culminated in efforts to create the Stop the Bleed Campaign, which aims to empower the layperson to render aid in a life-threatening bleeding emergency. As of February 2020, the program has held over 86,000 courses, trained over 1.4 million attendees, and over 77,000 instructors since its inception. In addition to spreading within the United States, American College of Surgeons (ACS) Stop the Bleed (StB) classes have been held in 118 different countries. This systematic narrative review aims to answer the following research question: What does the ACS StB Initiative do well, and where can it improve?

Materials and Methods:

The following search terms were utilized: "Stop the Bleed," "American College of Surgeons," "bleeding control," "first-aid," tourniquet, "wound pack," "direct pressure" hemorrhage, and bystander. The inclusion criteria were that the article needed to speak to the program or some aspect of bystander first aid, the article needed to be in a civilian setting, the article needed to be more than a case study or overview, and the first aid tools needed to be in the StB curriculum. 4 databases were searched, which produced 138 articles for screening. One hundred four full-text articles were able to be retrieved, and 56 articles were determined to meet the inclusion criteria once the full text was reviewed.

Results:

Fifty-six articles were included in the final review and were placed into the following categories: Needs Within the Community, Confidence and Knowledge, Training Modalities, Barriers and Gaps in Training, Instructor Selection, Skill Retention, and Patient Outcomes. The articles were then organized into each outcome for synthesis and reporting of the results. The program overwhelmingly improves short-term confidence, but gaps in skill retention, data collection on patient outcomes, and settings that would benefit were identified.

Conclusion:

StB is an effective tool in building confidence in laypersons, which is its biggest strength. A review of the literature shows several areas where the curriculum and materials could be better developed. Research can also be further refined to better quantify the program's impact.

In 2013, The Hartford Consensus brought together subject matter experts across multiple disciplines in health care and public safety to create guidelines and publications intended to improve survivability in active shooter events. Among the recommendations was the need for earlier recognition and treatment of life-threatening hemorrhage.[1] At the annual Hartford Consensus in October 2015, these efforts expanded to recommend a nationwide campaign for laypersons providing bleeding control.[2,3] Based on these recommendations and mandates from the White House, the Department of Defense developed the Stop the Bleed (StB) program pursuant to a licensing agreement with The American College of Surgeons (ACS).[4] This effort has produced valuable instructional content, classes for the public, and the means to place bleeding control kits in communities. Various professionals are eligible to become ACS-StB instructors, including physicians, allied health care personnel, and nonclinical injury prevention coordinators. Students in these disciplines can be associate instructors but cannot coordinate an ACS-StB course independently.[5] As of February 2020, the ACS-STB program has held over 86,000 courses, certified over 77,000 instructors, and trained over 1.4 million attendees. In addition to the United States, ACS-StB classes have been held in 118 different countries.[6] In its current form, ACS-StB classes are taught with a didactic and a hands-on portion. Materials are available on bleedingcontrol.org, and the website assists local instructors in outreach by providing a platform to announce future classes. Instructor content is based on the Bleeding Control 2.0 curriculum and includes rescuer

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safety considerations, calling 911, utilizing direct pressure, wound packing, and tourniquet use. American course material includes recommendations for 10 different tourniquets approved by the Committee on Tactical Combat Casualty Care. Recommended tourniquets include the Combat Application Tourniquet (CAT) 6 and 7, SOF Tactical Tourniquet-Wide (SOFTT-W), and the Ratcheting Medical Tourniquet. However, the only tourniquet with a video demonstration is the CAT. At the time of this publication, the ACS offers online delivery of the didactic portion in response to the COVID-19 pandemic.[7] Currently, there is no continuing education requirement for ACS-StB, yet other forms of bystander first aid, such as CPR, require some form of refresher training. The American Red Cross makes skill refresher applications available in addition to offering hands-on training.[8] This systematic narrative review aims to answer the following research question: What does the ACS-StB Initiative do well, and where can it improve?

METHODS

The authors developed a list of key terms to inform the search process, including "Stop the Bleed," "American College of Surgeons," "bleeding control," "first-aid," tourniquet, "wound pack," "direct pressure," "hemorrhage," and "bystander." The study was not registered but utilized the PRISMA 2020 checklist as a guideline.

The inclusion criteria included: the article must speak to some aspect of ACS-StB or bystander first aid of a traumatic injury; the topic had to be on prehospital bleeding control; the article could not be on prehospital bleeding control in an operational/deployed military environment; the article must offer more than an overview or history of the program; the full text of the article needed to be available through the authors' respective institutions; and the article needed to be available in English. Articles discussing bleeding control measures other than limb tourniquets, direct pressure, or wound packing were excluded since those tools are not in ACS-StB material. Case studies were too subjective to provide insight into the efficacy of a program and were excluded. The search was limited to publications since 2015 because the StB Initiative started in late 2015.

The following electronic databases were searched from September to October 2021: MEDLINE (EBSCOhost), Cochrane Central Register of Controlled Trials (Wiley), CINAHL Complete (EBSCOhost), and Embase (Elsevier). Exclusion terms to narrow the search were developed for each database. The primary author conducted all initial screening, and the two authors worked collaboratively to determine if articles sought for retrieval still met eligibility criteria.

The search identified 571 articles. There were 166 duplicate articles across more than one database, leaving 138 articles for screening after the duplicates were removed. The abstracts were manually screened for inclusion criteria based on title and abstract; 138 articles were subsequently sought for retrieval. The authors were unable to access the full text for 34 articles; these articles were excluded. The full-text versions of 104 articles were assessed for whether they met the inclusion criteria, which ultimately left 56 articles in the review.

After reviewing the full-text versions of each article, the authors identified the following primary outcomes: Need Within the Community, Confidence and Knowledge, Content Delivery, Barriers and Gaps in Training, Instructor Selection, Skill Retention, and Patient Outcomes. The articles were then organized into each outcome for synthesis and reporting of the results (Fig. 1) (Supplementary Table S1).

RESULTS

Need within the Community

Six articles examined where additional community engagement would be particularly beneficial. Postmortem reports from Maryland between 2002 and 2016 showed 124 out of 288 civilian deaths were preventable by tourniquet use according to military standards.[9] Other reviews specific to fatal hemorrhage between 2012 and 2017 in Maryland from AV fistulas found six tourniquet-preventable deaths per year.[10] Wend et al.[11] evaluated nationwide tourniquet use following animal attacks from 2010 to 2019. In these animal attacks, 60% of tourniquets were improvised and 58% were applied by laypersons. While these articles show where bleeding control training may provide benefit, there is no posttraining comparison.

Goolsby et al.[12] investigated mass-casualty terrorist attacks and noted public entertainment venues were most targeted, but other locations included religious locations and education centers. Blasts were more likely to produce more injuries amenable to bleeding control than shootings. Ramchandra et al.[13] identified freeways in India as high-yield locations for bleeding control efforts, as motor-vehicle collisions also produce injuries amenable to bleeding control techniques. They identified barriers to rendering aid, such as lack of confidence, pressure from passengers within a bystander's vehicle, and potential legal trouble, specifically amongst taxi-cab drivers.

Untrained laypersons appear to have a poor rate of success with tourniquets. Ross et al.[14] noted a 16.9%, 23.4%, and 10.6% tourniquet success rate with a Combat Application Tourniquet (CAT), Ratcheting Medical Tourniquet (RMT), and Stretch Wrap and Tuck Tourniquet (SWAT-T) respectively amongst untrained persons. Additionally, Khorram-Manesh et al.[15] noted the discrepancy between perceived first-aid priorities between untrained personnel and medical professionals, but these discrepancies were largely corrected following first-aid training based on before and after surveys.

Confidence and Knowledge

In 21 articles, confidence or knowledge were primary outcomes. In schools, ACS-StB efforts have consistently improved confidence in bleeding control. Literature on students and staff all show increases in postcourse confidence in carrying out bleeding control skills compared to before attending a class.[16–20] School personnel are more likely to report

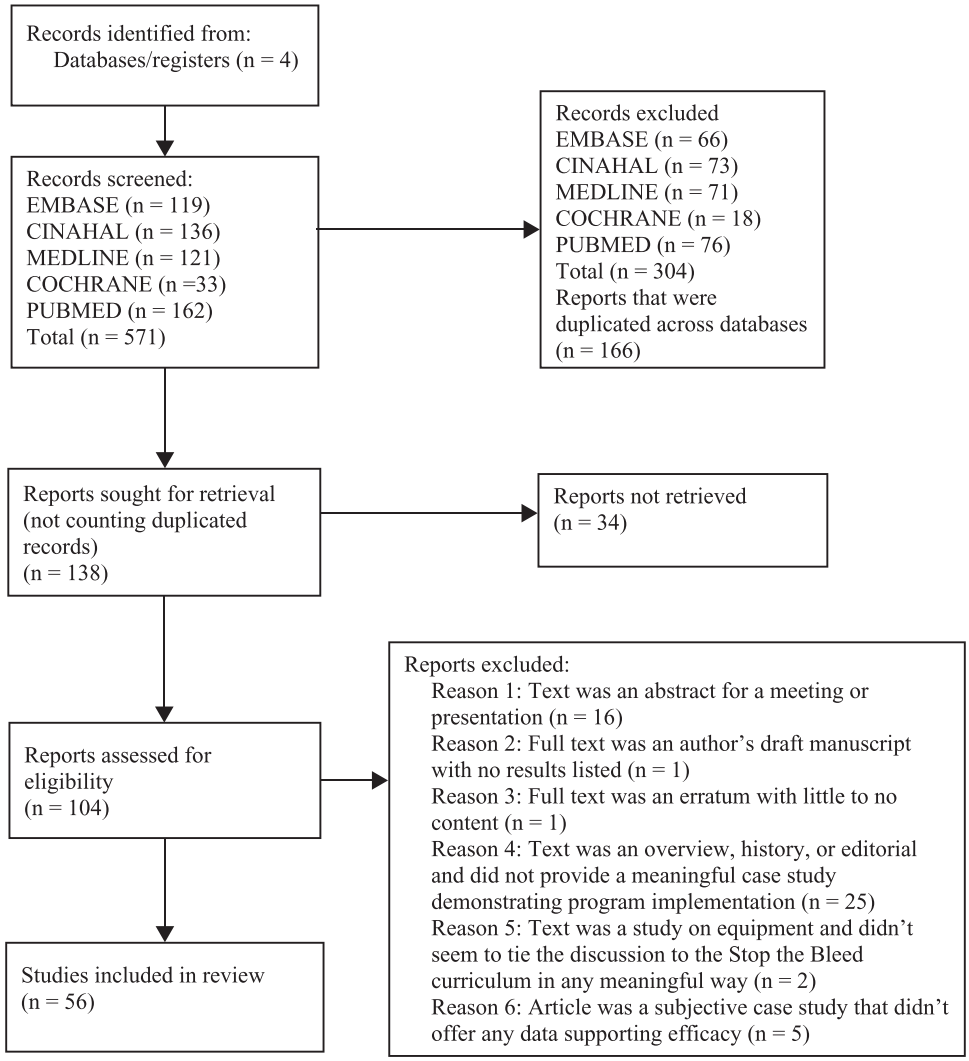

FIGURE 1. Flow chart detailing the process for inclusion.

willingness to render aid in a hemorrhagic emergency after attending a class. Additionally, posttrauma inpatient participants were willing to provide emergency care in a future traumatic situation.[21] Several studies found the same results in their research on medical school students and health care employees.[22–26]

The literature on the general population shows similar results. Schroll et al.[27] identified significant differences in precourse and postcourse groups as well as a 99.3% rate of demonstrated proficiency. Ross et al.[28] noted significant, positive differences in tourniquet knowledge and bleeding control knowledge in a sample of the general population. Other data included self-reported barriers to rendering aid, such as lack of training, fear of making a mistake, and fear of causing harm. Andrade et al.[29] found significant differences in postcourse confidence between community members who were given a bleeding control kit after training and community members who were not.

Five articles discussed ACS-StB postcourse confidence outside the United States. Smith et al.[30] found substantial increase in postcourse confidence across both tourniquets and wound packing in their sample in India. In Japan, Morishita[31] noted that Japanese health care providers rated their postcourse bleeding control confidence on average at 86%. However, there was no precourse survey for comparison. In another Japanese study, Ito[32] utilized a knowledge quiz and reported an improvement from 42% to 62%. AlSabah et al.[33] noted positive reception in their participants in Kuwait, with 89% of participants reporting increases in the perceived utility of ACS-StB after attending. In Spain, Yanez et al.[34] reported an 84% course satisfaction rate. Neither study utilized other experimental or control groups.

Bobko et al.[35] used scenarios to measure a first care provider (a precursor to ACS-StB) trained group and an untrained group against one another in a simulation, with the

trained group showing a threefold decrease in the time it took to resolve both airway and bleeding issues.

Content Delivery

Eight articles explored content delivery. Portela et al.[36] utilized the manufacturer instructions for the CAT, RMT, SWAT-T, and SOFTT tourniquets with untrained laypersons, finding successful application rates of 53.7%, 63.4%, 22.5%, and 61.4%, respectively. Lowndes et al.[37] utilized an ACS-produced visual guide and compared it to manufacturer instructions. When applying a CAT, there was a significantly lower rate of failure ($P < .05$) and time to apply a tourniquet when using ACS instructions.

Goralnick et al.[38] compared a full course, audio instructions, and instructional flashcards with a no-training control. Success rates in tourniquet (CAT) application were 87.7%, 23%, 19.7%, and 16.3%, respectively. The only significant difference between the control was with the full course. Goolsby et al.[39] found significantly higher success in instructor-led and blended (distance learning combined with in-person training), compared to online-only content delivery. Goolsby and Schuler[40] found a significant increase in successful tourniquet application rates with "virtual-in-person" training or a virtual, interactive didactic portion followed by an in-person hands-on portion; however, they did not compare it to other delivery methods. Zwislewski et al.[41] noted significant differences between the higher success rate of hands-on training groups versus a group with only didactic instruction.

Different instruction and evaluation techniques were discussed in two articles. Muret-Wagstaff et al.[42] were able to produce a 100% success rate in meeting an objective skills assessment via a step-by-step demonstration method but did not use a control group. Pellegrino et al.[43] developed the Stop the Bleed Educational Assessment Tool (SBEAT). This tool utilizes a list of standard performance measures, separated by the level of the attendee (e.g., lay person or medical professional), to measure bleeding control proficiency after receiving instruction. When evaluated by a Cronback Alpha (KR-20) person score "test reliability," scored 0.85, indicating moderate test-retest reliability.

Barriers and Gaps in Training

Nine articles addressed a gap in the ACS-StB curriculum or delivery. One issue discussed in depth was operating costs as a barrier to implementing quality training. Motameni et al.[44] tracked costs during their implementation of the program and found an average estimated cost of $729 per 25 trainees.

Blood loss estimation was investigated by Prytz et al.[45] Despite ACS-StB recommendations that 165 ml of blood loss should be treated as life threatening, a third of their participants reported that they would not use a tourniquet at 150 ml of blood loss. A significant difference in perceived severity of blood loss was also found, with participants perceiving lower levels of blood loss as more severe in males than females.

Stadeli et al.[46] investigated cultural barriers to bleeding control and emergency service utilization. Qualitative results indicated that many members of the Somali community distrusted the legal and medical systems in the United States, which was addressed by a tailored curriculum. Stadeli et al. also noted a dramatic increase in this community's willingness to render aid after training (65% before training to 93% after training).

Gupta et al.[47] utilized a perfused synthetic cadaver model, with all participants reporting a more realistic experience and a better understanding of blood flow from an arterial wound. Villegas et al.[48] surveyed postcourse participants regarding perceived realism of a nonbleeding model. The median rating was 80%, but all 310 survey participants reported a bleeding simulation would have made the model better.

Charlton et al.[49] evaluated direct pressure techniques. Less gauze material was associated with more pressure, two hands provided more pressure than one, and single-handed manual pressure was associated with more pressure than all tested pressure wrap techniques. Despite these nuances, ACS-StB material does not address them.[7] McCarty et al.[50] evaluated proficiency of postcourse participants across several tourniquet types, including SOFTT, SWAT-T, RATS tourniquets, and improvised tourniquets against the CAT. When compared to the CAT, success rates were significantly lower (92.2% for the CAT, 68.6% for the SOFTT, 11.8% for the SWAT-T, 11.8% for the RATS, and 32.4% for the improvised tourniquet).

Dhilon et al.[51] evaluated postcourse attendees and whether they acquired their own bleeding control equipment. Despite high measures of self-reported desire to acquire material, only 21.3% of their attendees had acquired a tourniquet after a month. Commonly cited barriers were cost, time, and accessibility. Zhao et al.[52] utilized qualitative survey results from postcourse attendees to make recommendations to ACS-StB implementation. The most common recommendation was to provide refresher material and bleeding control kits.

Instructor Selection

Four articles focused primarily on evaluating instructor efficacy. Jacobs et al.[53] evaluated the reception of ACS-StB amongst surgeons. While the findings indicated surgeons would be receptive to the curriculum, there was no evaluation of their training delivery modality. Moton et al.[54] studied pharmacists, using confidence and correct tourniquet placement as measures of success. While there were significant improvements in precourse and postcourse performance, the study design did not incorporate a control.

Medical students were evaluated in two of the four articles. Schroll et al.[55] recruited medical students to complete the course, followed by an objective assessment of their instructor skills. The authors concluded that medical students were capable of teaching ACS-StB. Orlas et al.[56] compared medical students and surgeon instructors and found course attendees

reported no statistical difference in confidence or skills after taking courses taught by students versus those taught by surgeons.

Skill Retention

Six articles discussed skill retention following course attendance. Palsey et al.[57] found 40% attendees correctly applied tourniquets after a month. Weinman[58] found attendees were successful in tourniquet application 61% of the time after six months. McCarty et al.[59] evaluated individuals who self-reported training. Findings showed only 35% of individuals with first aid and hemorrhage control training successfully performed bleeding control tasks despite very high self-reported confidence in bleeding control skills. Nicholas et al.[60] evaluated the use of a phone application by participants who had attended a bleeding control course a year prior. While the majority of both the control and experimental groups could not perform bleeding control skills and demonstrate satisfactory situational awareness in a simulated mass casualty exercise, there was a significant difference in successful tourniquet application. Chaudhaury et al.[61] found a 55% tourniquet success rate at 3–9 months after StB training was delivered to employees of a large event space.

One study evaluated different methods of continuing education modes. Sainbayer et al.[62] utilized refresher videos on bleeding control skills. Despite higher self-reported confidence, the experimental group did not score better on bleeding control quizzes than a control group.

Patient Outcomes

Two studies specifically discussed long term-tourniquet increases in prehospital tourniquet use, Hartford Consensus guidelines, and patient outcomes. Henry et al.[63] studied patient outcomes in Los Angeles County between 2015 and 2019. Of 944 patients, 10.3% had prehospital tourniquets with significant differences in survival and transfusion requirements between patients with tourniquets and without. Although results also showed a linear increase in tourniquet use, it is unclear whether tourniquets were applied by EMS personnel or ACS-StB-trained first responders. Research by Teixeira et al.[64] covered Texas hospitals between 2011 to 2016 and found tourniquet use associated with greater odds of survival compared to similar patients who did not have tourniquets applied. Unfortunately, data collected in this study also does not include who is applying the tourniquet.

DISCUSSION

The original research question requires the evaluation of what the ACS-StB does well and where it can improve. ACS-StB's biggest strength according to the literature from Confidence and Knowledge is the generation of confidence amongst laypersons. Postcourse confidence is one of the more heavily explored topics in the literature. Every article that evaluated confidence and self-reported willingness to render aid reported positive effects of attending a course.

The results can inform several specific recommendations for ACS-StB:

Create Instructor and Program Development Material

Literature from Barriers and Gaps in Training and Content Delivery support this suggestion. Hands-on training remains an important aspect of ACS-StB curriculum.[39,41] A "blended" curriculum that combines self-study with in-person instruction is a viable option, but effective instruction still requires some form of hands-on training. Instructor material does not offer a "how-to" teach, despite evidence suggesting that this may improve outcomes. Step-by-step demonstration may help with instruction and explain some of the discrepancy between hands-on experimental groups and non-hands-on experimental groups. The SBEAT appears in two publications, including Goolsby et al.[40] work assessing virtual content delivery. The SBEAT serves as a clinical assessment tool and appears to be a potentially useful tool in assessing training outcomes in with ACS-StB. Current material offers no way for instructors to evaluate how well attendees understand bleeding control concepts. While Bobko et al.[35] evaluated an ACS-StB precursor, the use of simulation and scenarios to evaluate outcomes might also be beneficial. Offering instructors "best practices" and performance measurement tools may improve program outcomes.

Instructor materials do not provide recommendations for prospective program coordinators; this can be problematic given the cost associated with training even 25 students.[44] Instructors may also want to improve the quality of their training tools, as perfused cadaver models show potential.[47,48] Program coordinators may want to explore bleeding control kit placement and distribution as many who attend an ACS-StB course struggle with acquiring material afterward.[51,52] This could be accomplished by providing an online forum where instructors can share lessons learned.

Develop Refresher Material or Curriculum

Bleeding control skills are perishable, as indicated by literature from Skill Retention. The current model of a block of instruction with no continuous training cannot guarantee performance during an emergency, as simply claiming to have training is insufficient.[59] A tourniquet success rate can be maintained at about 55% within a structured curriculum,[61] and refresher training should happen at least every 6 months.[58] While this can be feasible for some employers, this may not work for the general population. Other ways to refresh knowledge should be explored.

The use of smaller blocks of continuing education shows some promise,[62] but the literature does not support the idea

that videos can be used to sustain bleeding control knowledge. There are mixed results with "just-in-time" training or an equivalent. Manufacturer instructions for tourniquets may not be sufficient half the time,[36] but the quality and usability of instructions should be considered.[37] This should be explored further, as stricter refresher training requirements comes at a cost of accessibility to laypersons. This could be done in the form of applications, just-in-time instructions in bleeding control kits, or public-service announcements.

Tailor Material for Global Health and Immigrant Populations

Literature from Confidence and Knowledge and Barriers and Gaps in Training support this suggestion. Some unique global health issues in the discussions included the impact of rural conditions on trauma outcomes in India,[30] the lack of trauma exposure in general in Japan, and the overflow of violence from war-torn countries around Kuwait. As noted by Smith et al.,[30] India lacks a refined prehospital EMS system and is behind on standards set by the World Health Organization. Bystander intervention may be a necessity in this setting. Morishita[31] and Ito[32] pointed out the lack of trauma and trauma awareness in Japan. This translates to trauma treatment that is not consistent with best practices.

Even within the United States, health equity issues arise when accessing emergency medical services. Culture heavily impacts outcomes, and there is no material on engaging these populations who may hold mistrust of emergency medical systems stemming from their home country.[46] ACS-StB material offers an Australia and even Texas-specific presentation[7]; this should be expanded to include other countries and cultures.

Expand Content to Include Interventions Other than the CAT and Different Mechanisms of Injury

Literature from Barriers and Gaps in Training support this suggestion. Pressure techniques may require more nuanced instruction given the differences in outcomes between different techniques,[49] which is not reflected by material on bleedingcontrol.org.[7] In addition, despite recommending several tourniquet types in the instructor materials, there are only video demonstrations for the CAT. Tourniquet skills may not carry over across different models,[50] so improving content in this area may benefit the initiative.

Some ACS-StB material discusses the mechanism of injury, but this discussion is not very in-depth. Animal bites, blast injuries, and automobile accidents present unique injury patterns and provider safety considerations, and literature suggests that these are high-yield locations to focus on.[11,12,15]

Continue to Broaden List of Eligible Instructors

Literature from Instructor Selection supports this suggestion. The large pool of eligible instructors can help proliferate the ACS-StB initiative. The literature suggests a variety of instructors, including medical school students, can deliver course content. The literature does not seem to suggest an ideal instructor background; however, it is worth noting is that medical students are still not eligible to independently organize and teach ACS-StB but can assist with instruction. The literature suggests medical school students are capable ACS-StB instructors.

Perform Further Study on Bleeding Control in the Field

Literature from Need Within the Community and Patient Outcomes support this suggestion. Tourniquet use is increasing in civilian prehospital medicine and is producing sustained and positive patient outcomes over a span of years. Henry et al.'s[63] experience in Los Angeles indicates tourniquet use increased during their study period, and all reviewed literature cites the Hartford Consensus and efforts by the ACS as contributing factors in increasing tourniquet use.

Literature on this topic does not discuss who is applying the tourniquet (bystander or first responder), how long it takes to apply a bleeding control intervention, or adjuncts other than tourniquets. Additionally, while research using postmortem reports do a good job of identifying patients that would benefit, they are often missing the previously listed key details and do not attempt to measure a benefit from the broad implementation of ACS-StB.[9–11] In its current form, the literature can suggest where outreach might provide benefit but cannot answer if it does or by how much it benefits.

Further Refine Research Questions and Experimental Design

Postcourse confidence has been identified as a major strength by literature from Confidence and Knowledge. What the literature does not evaluate is confidence over time and whether it deteriorates the further an attendee is from their last ACS-StB course. Additionally, many of these studies neglect using a control group. Some interesting lines of inquiry could also include unique populations such as Van Winkle et al.[21] research on posttrauma victims. Future research should strive for more robust experimental designs or nuanced research questions.

CONCLUSION

ACS-StB has achieved substantial reach since its inception in 2015. The program does a good job of improving self-reported confidence in laypersons should they encounter a life-threatening bleeding emergency. However, a systematic review of the literature on the program shows several areas where the curriculum could be better developed or research questions can be better defined. Material specific to improving instructor development, refreshing knowledge, addressing global health or cultural barriers to emergency health care, and bleeding adjuncts other than the CAT would benefit the program. Additionally, future research can better build on the

existing literature by exploring specific nuances, using more robust data collection techniques, or more extensive experimental designs to quantify the benefit on trauma outcomes.

Overall, ACS-StB is a valuable tool for countless stakeholders in community health and safety. The value of the program should not be discounted, and further work should be done to bring the initiative to its full potential across the world.

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SUPPLEMENTARY MATERIAL

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CONFLICT OF INTEREST STATEMENT

None declared.

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