Disaster Medicine and Public Health Preparedness

www.cambridge.org/dmp

Original Research

Cite this article: Dadario NB, Shleiwet NH, Santana Felipes RC, *et al*. Use of cognitive aids to augment point of care hemorrhage control skills in laypersons. *Disaster Med Public Health Prep*. **17**(e428), 1–7. doi: https://doi.org/10.1017/dmp.2023.92.

Keywords:
active shooter; hemorrhage control; tourniquet; wound packing; stop the bleed

Corresponding author:
Nicholas B. Dadario;
Email: nicholas.dadario@rutgers.edu.

Use of Cognitive Aids to Augment Point of Care Hemorrhage Control Skills in Laypersons

Nicholas B. Dadario BS[1], Nicholas H. Shleiwet BS[2], Rachel C. Santana Felipes BS[3], Brennan Cook BS[1], Joseph V. Cooney BS[4], Karen M. Stephenson BS[5], Michelle Elsmore BS[6] and Farrukh N. Jafri MD[3]

[1]Robert Wood Johnson Medical School, Rutgers University, New Brunswick, New Jersey, USA; [2]Columbia University College of Dental Medicine, New York, New York, USA; [3]Department of Emergency Medicine, White Plains Hospital, White Plains, New York, New York, USA; [4]Touro College of Osteopathic Medicine, Middletown, New York, USA; [5]Jacobs School of Medicine and Biomedical Sciences, University of Buffalo, Buffalo, New York, USA, and [6]Department of Biological Sciences, Binghamton University, Binghamton, New York, USA

Abstract

Objective: The Stop the Bleed course aims to improve bystander hemorrhage control skills and may be improved with point-of-care aids. We sought to create and examine a variety of cognitive aids to identify an optimal method to augment bystander hemorrhage control skills in an emergency scenario.

Methods: Randomized trial of 346 college students. Effects of a visual or visual-audio aid on hemorrhage control skills were assessed through randomization into groups with and without prior training or familiarization with aids compared with controls. Tourniquet placement, wound packing skills, and participant comfortability were assessed during a simulated active shooter scenario.

Results: A total of 325 (94%) participants were included in the final analyses. Participants who had attended training (odds ratio [OR], 12.67; $P = 9.3 \times 10^{-11}$), were provided a visual-audio aid (OR, 1.96; $P = 0.04$), and were primed on their aid (OR, 2.23; $P = 0.01$) were superior in tourniquet placement with less errors ($P < 0.05$). Using an aid did not improve wound packing scores compared with bleeding control training alone ($P > 0.05$). Aid use improved comfortability and likelihood to intervene emergency hemorrhage scenarios ($P < 0.05$).

Conclusions: Using cognitive aids can improve bystander hemorrhage control skills with the strongest effects if they were previously trained and used an aid which combined visual and audio feedback that they were previously introduced to during the course training.

Over the past 20 y, there has been a consistent increase in active shooter incidents in the United States.[1] Prompted by this rise in mass casualty incidents, the White House, alongside the American College of Surgeons (ACS), launched the Stop the Bleed (STB) program to prepare the public as immediate responders in these events for preventable hemorrhagic death.[2] The STB program educates bystanders with a Bleeding Control (B-Con) course that teaches appropriate situational awareness, tourniquet application, and wound packing techniques.[2–4] Given up to 50% of all civilian trauma deaths are due to hemorrhage and occur within 3 h of hospital arrival, prehospital hemorrhage control represents a fundamental way to reduce the incidence of preventable hemorrhagic deaths.[5] As such, there has been growing interest by many in teaching the B-Con course while also examining potential avenues for improvement within the general public.[6]

Several alternative methods for B-Con teaching have been examined as a means to augment bystander skills in real time.[6–8] Studies have tested a variety of both in-person and online training methods as well as point-of-care aids without previous training and found that some form of in-person training remains optimal.[8–10] Building off this work, our team found that adding high-fidelity simulation techniques to the B-Con course can significantly improve short-term hemorrhage control skills. However, shared among many studies was a growing concern about the retention of skills in as little as 6 mo.[11] To better understand how to improve retention, our team further examined the use of a publicly available instructional aid as a point-of-care device and found that it can enhance tourniquet skills and confidence 1 y after initial training.[6] Not surprisingly, similar benefits with instructional aids as a point-of-care device have been found in several other bystander programs, such as cardiopulmonary resuscitation (CPR).[12] However, available aids for the B-Con course remain preliminary and incomplete as they do not address many key aspects of the B-Con course, such as wound packing.[6,8] If instructional aids are to be soon implemented as a regular component of the B-Con course or in public bleeding control kits, further work is necessary to improve our current understanding of how to best develop and implement cognitive aids to augment bystander hemorrhage control skills.

SDMPH
SOCIETY FOR DISASTER MEDICINE & PUBLIC HEALTH

To address this gap, the current study sought to create and examine a variety of cognitive aids to identify an optimal method to augment bystander hemorrhage control skills in an emergency scenario. Specifically, our team created visual and visual-audio aids based on the critical components of the B-Con course and data from previous studies. The optimal instructional aid and method of training or delivery were examined based on the primary outcomes of tourniquet success rate and wound packing performance. Secondary outcomes examined the most common reasons for failure in hemorrhage control skills and survey data to identify further information that may be used to refine these aids in the future. Ultimately, the current work may provide valuable data on how to effectively incorporate instructional aids into the B-Con course to meet pre-defined STB objectives.

Methods

Study Design

This study is an open label, prospective randomized trial reported according to the CONSORT guidelines for randomized trials[13] (SDC1). A prospective sample of student participants from a single institution at a State University in New York were openly invited to participate in a 30-min study administered from October 2019 to January 2020. This study received approval from the Institutional Review Board (STUDY00001802). All participants gave their written informed consent before their participation.

Study Participants and Instructors

Student participants were recruited by electronic mail distributed to numerous university clubs and organizations on campus. The inclusion criteria included participants over 18 who had not previously taken the B-Con course. The exclusion criteria included participants previously trained in hemorrhage control skills or the B-Con course. The program started with all participants becoming trained and certified in a 2-h B-Con course before beginning a 30-minute testing period. These courses were taught in person at the university by certified instructors who were part of the university's emergency medical services (EMS) devoted to STB Training. The STB division of the EMS services included specialized B-Con trainers who earned their certification and completed extensive training in bleeding control within their department for the unique purpose of teaching the B-Con course as previously described.[6] Participants designated to complete testing before B-Con training were scheduled for B-Con training the following day after testing. At all times, participation in training and/or the trial was optional and could be withdrawn. Our study team included 10 study instructors who were part of a bystander awareness program at the university founded by the principal investigator (N.D.) and were extensively trained in STB B-Con 1 mo before assisting in the study. All the instructors also took part in 2 "Train the Trainer" programs before the start of the study, which consisted of instructors demonstrating an understanding of the aids provided in the study, recalling essential concepts from the B-Con training, and reviewing a standardized rubric created and previously used by the author.[6,7]

Study Protocol

Before starting the study portion, participants were given consent forms and listened to the study description. Participants were pre-assigned into 1 of 3 study group groups each day: (1) Visual-Audio aid (instructional video on a mobile phone), (2) Visual aid (infographic card), or (3) no aid (control). Furthermore, 1 of the study's objectives was to identify the best methods to implement cognitive aids in the public based on varying training methods. Therefore, these aids were also examined based on further randomization into groups *with* and *without* prior familiarization with the aids ("priming") before testing as well as *with* and *without* B-Con training before testing (*expanded further in Interventions section*). In total, this constitutes 8 study arms (Figure 1) to understand the optimal cognitive aid delivery method. Priming days were randomly determined on an alternating day schedule such that 1 d was primed or not primed and then rotated the following study day. Participants were randomized in a 2:1 ratio for training and no training groups, respectively. Nontrained groups received B-Con training after testing.

Cognitive Aid Intervention

Participants who were assigned a visual or visual-audio aid used these aids during both tourniquet and wound packing testing. These aids included either a visual infographic (VIS) card or instructional videos with audio overlay (VA) description of step-by-step appropriate scene safety, tourniquet application, and wound packing skills as taught in the B-Con course. These aids are expanded upon and included in the Supplementary Digital Content (SDC2, Figure; SDC3, Video; and SDC3, Video). "Priming" days referred to sessions at which participants at the end of their B-Con training received a 5- to 10-min instructor presentation in their respective groups of the components of their cognitive aid to be utilized. This priming did not include additional hands-on training, but rather a short oral instructor description and demonstration. The control group did not receive any priming and waited until the other groups were primed entirely. The aim was to understand if the efficacy of the aid in hemorrhage control skills depended on prior familiarization with the aid.

Given the open-label essence of the study, instructors on the study team were also assigned randomly to 1 study arm for each testing session. Both the instructors and participants were not blinded and were fully aware of their given intervention group.

Testing

After the participants were divided into their designated interventions, both groups completed a testing period followed by a postsurvey, which the study instructors administered. Ultimately, time between training and testing was kept at a minimum and did not exceed 30 min at any point. The testing period took place at 3 different types of testing stations, including: (1) a wound packing station, (2) a tourniquet station, and (3) a survey station. The stations were all isolated to maintain a 1:1 ratio of instructor to participant. Therefore, the number of wound packing and tourniquet stations available on a given day depended on the number of participants present.

Tourniquet Testing

Testing for tourniquet placement and situational awareness skills occurred at the same tourniquet station by using an emergency simulation scenario requiring bleeding control on a low-fidelity mannequin limb. The VA and VIS groups underwent our intervention at this station. Both the VA and VIS participants were given 60 s before the assessment to visually review their interventional aids without using the mannequin leg or tourniquet,

https://doi.org/10.1017/dmp.2023.92 Published online by Cambridge University Press

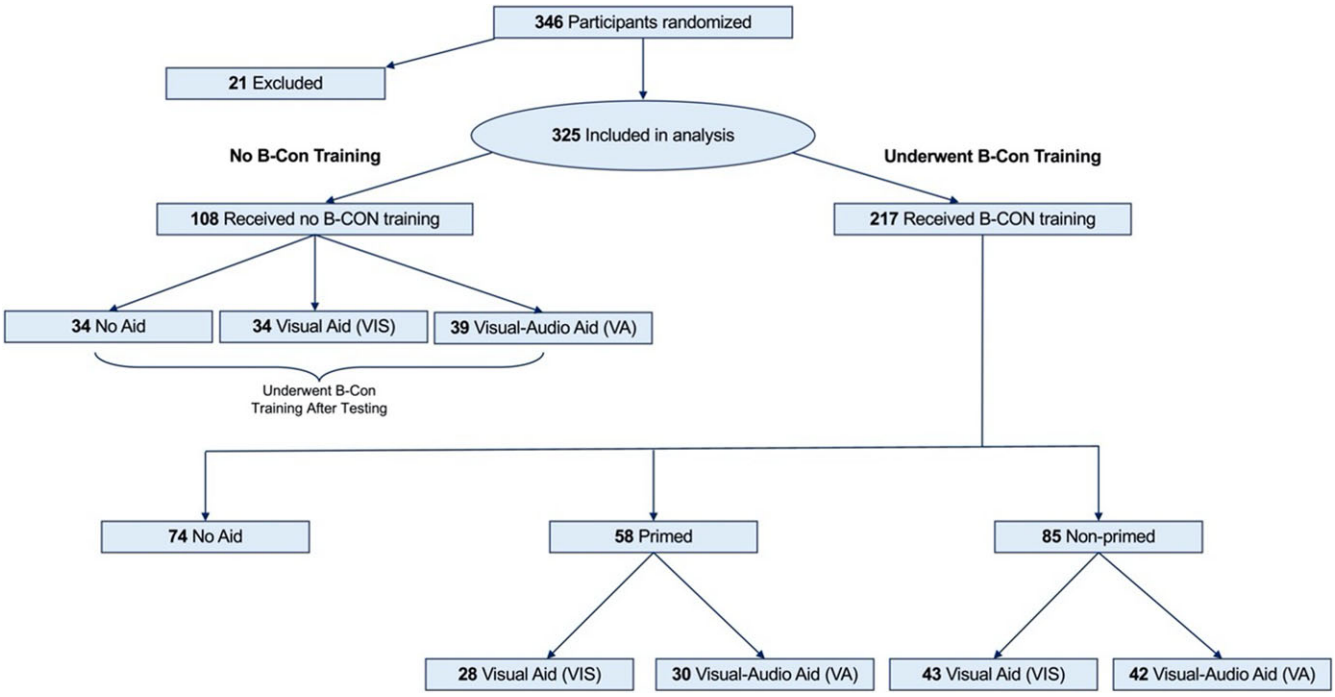

Figure 1. Study flow diagram. Among the students in SUNY Binghamton University contacted, 346 were enrolled and participated in the study. Participants were excluded, given previous experience with the Bleeding Control (B-Con) course or spontaneous withdrawal. Students were randomly selected to participate in the B-Con course and were either introduced to the intervention (primed or not primed) or no intervention before testing. Interventions included a visual aid (infographic card) or a visual-audio aid (instructional video). Participants who did not undergo B-Con training before testing received training afterward.

regardless of their prior priming intervention or not. All VA and VIS participants were strongly encouraged by the instructors to use the entire 60 s to review their respective interventional aids to ensure consistent exposure to the aids among all groups. The limited instruction to participants and the 60-s review period are factors implemented in this study to simulate the point-of-care use of their assigned interventional aids upon engaging in a real hemorrhage control scenario. After completing the 60-s review period, VA and VIS participants were introduced to the simulated emergency scenario. In contrast, the control groups (B-Con) were not given any interventional aids and were immediately introduced to the emergency scenario at the start of the assessment.

To simulate an emergency scenario, instructors read aloud a short prompt of an emergency scenario (SDC5, Text; SDC6, Text) necessitating bystander intervention and were notified that a combat application tourniquet (CAT-7) was available if needed. Furthermore, participants were directed to articulate their thought processes and actions during the assessment verbally. Upon completing the emergency scenario prompt, participants were confronted with a low-fidelity mannequin arm with a gunshot wound moulage and a nearby CAT-7 on the floor. In all study groups, participants received no instruction during testing regarding situational awareness or tourniquet placement. The participants were also made aware that the scenario would be complete once they verbally let the instructors know that they finished applying the tourniquet to the best of their abilities.

The instructors evaluated participants' performance in all groups regarding their situational awareness and proper tourniquet application using a previously described rubric.[6,7] In brief, the rubric consisted of 2 components—situational awareness skills and proper tourniquet placement—as outlined by the ACS B-Con course. Situational awareness skills included the following: (1) Dialing 911, (2) Assessing the safety of the scene, and (3) Correctly describe a wound that would necessitate hemorrhage control. The evaluation scores for each action were binary, with a yes/no answer based on whether each concept was communicated or performed by the participant. Proper tourniquet placement was assessed using methodology adapted from previous studies[8,10] and modified by the authors in previous work.[6] The tourniquet application was considered properly applied if it was at least 2 inches above the wound, not applied on a joint, and had the necessary tightness, as described in the ACS B-con course. The tourniquet was considered to have the appropriate tightness if a finger could not easily be placed between the tourniquet and the limb surface. Tourniquet success was determined if all the steps were adequately performed and in the correct order. Incorrect attempts were recorded according to the reason for an incompletion. Additionally, the time required for placement by the participant was recorded from the start of the scenario until the participant's verbal completion of the tourniquet placement. The recorded time does not include the interventional aid review period in the VA and VIS groups. Further clarification of instruction for tourniquet station testers and scenario can be accessed in the supplemental material (SDC5, Text; SDC6, Text).

Wound Packing Testing

The wound packing testing was assessed using the Z-Medica Hemorrhage Control kit set to a standardized testing mode previously used by the authors.[6,7] The testing device displays a "packing score," which indicates the percentage of time that the participant applied pressure above 25 psi during the 90 s of the test. The 25-psi standard was distinguished from preceding studies using swine models, which determined this pressure to be adequate

https://doi.org/10.1017/dmp.2023.92 Published online by Cambridge University Press

to halt a femoral artery bleed.[14] During the wound packing scenario, participants were directed to pack the wound and apply pressure to the device for an unspecified period without further instruction regarding the 90-s interval or the 25-psi goal pressure. After each wound-packing evaluation, instructors confidentially documented participant scores and offered constructive feedback.

Survey

Upon completion of both the wound packing and tourniquet stations, participants were directed to answer a short survey regarding demographics, their degree of comfort in hemorrhage control principles, and their evaluation of their instructional aid's efficacy. This survey was modified from prior studies by the authors to evaluate participant perception of the likelihood of being engaged in and prepared for a future active hemorrhage scenario based on the above interventions.[6,7]

Statistical Analysis

All statistical analyses were performed using the statistical software R version 4.0.2. The Shapiro-Wilks test was used to determine normality. The primary outcomes of the current study were the dichotomous outcome of correct or incorrect tourniquet placement and the continuous outcome of wound packing score. Binomial logistic regression was used to compare tourniquet success rates. Logistic regression models were checked for the goodness of fit using the Hosmer-Lemeshow test. Linear regression was used to analyze wound packing grade. Both types were checked for extreme outliers by plotting Cook's Distance and multicollinearity using variance inflation factors. Secondary outcomes, including Likert survey data and additional data on tourniquet performance (eg, time to placement, number of errors), were analyzed with a mix of logistic and linear regression analyses as appropriate.

Results

Participants

A total of 346 participants were enrolled to participate in the study, of which 325 had never received formal STB training. Those who had previously undergone training were excluded from the analysis. Two-thirds of participants (217; 66.7%) were randomly allocated to receive B-Con Training, while the remaining third did not (108; 33.2%). Approximately half of those receiving B-Con training were then randomly assigned to receive priming (93; 42.8%) before tourniquet testing. All participants were then randomly allocated to receive a VIS (105; 32.3%), VA (111; 34.1%), or neither (109; 33.5%) at the time of testing (Figure 1). The median age of participants was 20 y old (range 17-25 y), and 45.6% were male. There were no significant differences in age or gender among the 3 groups, as determined by a Kruskal-Wallis rank sum test.

Primary Outcomes

Using multiple logistic regression, and controlling for age and gender, we found that participants who had attended class (OR, 12.67; $P = 9.3 \times 10^{-11}$), were provided a visual-audio aid (OR, 1.96; $P = 0.04$), and were primed on their aid (OR, 2.23; $P = 0.01$) had increased odds of correctly applying a tourniquet (Table 1; dems n = 325). Multiple linear regression was used to evaluate wound packing efficacy and found that attending class increased one's ability to better pack a wound (Estimate: 18.73; $P < 0.001$).

Table 1. Tourniquet and wound packing performance

Tourniquet placement Multivariable logistic regression			
Predictors	Odds ratios	CI	*P*-Value
Attended B-Con class	12.67	6.07 – 28.45	**<0.001****
Primed to aid	2.23	1.22 – 4.17	**0.011***
Age	1.08	0.85 – 1.39	0.530
Male gender	0.98	0.58 – 1.67	0.953
Visual-audio aid	1.96	1.04 – 3.77	**0.040***
Visual aid	1.05	0.56 – 1.98	0.877
Wound packing grade Multiple linear regression			
Predictors	Estimates	CI	*P*-Value
Attended B-Con class	18.73	9.26 – 28.20	**<0.001****
Primed to aid	7.60	−1.62 – 16.81	0.106
Age	2.30	−1.06 – 5.65	0.179
Male gender	21.43	14.05 – 28.81	**<0.001****
Visual-audio aid	7.94	−0.96 – 16.83	0.080
Visual aid	−0.18	−9.15 – 8.79	0.969

Abbreviation: B-Con, Bleeding Control; CI, confidence interval.
*$P < 0.05$.
**$P < 0.001$.

Next, performance was examined between groups which only attended the B-Con class, but did not use any aid compared with all participants which used an aid during tourniquet testing and wound packing. When using multiple logistic regression, and controlling for age and gender, there was a significant difference in correct tourniquet placement rates between groups (VIS OR, 0.05; $P < 0.001$ and VA OR, 0.25; $P = 0.0156$). When multiple linear regression was used to compare the same 2 groups with wound packing scores, there was a significant difference in outcome for those with a VIS aid ($P < 0.001$) but not for those with a VA aid ($P = 0.486$).

The same analysis using multiple logistic regression and multiple linear regression was repeated with respect to priming in the VIS and VA groups. There was no statistically significant difference in tourniquet success or wound packing grade for those using either a VA or VIS aid and primed versus those using a VA or VIS aid and not being primed (Tourniquet: VA, $P = 0.112$; VIS; $P = 0.575$. Wound Packing: VA, $P = 0.244$; VIS, $P = 0.475$).

Secondary Outcomes

The number of errors each participant made in applying a tourniquet was also assessed using multiple linear regression. Attending B-Con training (Estimate: −1.03; $P < 0.001$), being primed to an aid (Estimate: −0.35; $P = 0.003$), and using a visual-audio aid (Estimate: −0.34; $P = 0.002$) all were associated with a decreased number of tourniquet performance errors. Participants who used a visual-audio aid (OR; 3.05; $P < 0.001$) and were primed (OR; 2.85; $P = 0.002$) with its use were also more effective at recognizing the life-threatening wound.

The time to tourniquet placement was also recorded. The median time to apply a tourniquet was 80 s in the total study group. This time was reduced by being enrolled in the B-Con class, and extended by using an external aid, and being primed to an aid

https://doi.org/10.1017/dmp.2023.92 Published online by Cambridge University Press

Table 2. Tourniquet placement performance data

Number of errors Multiple linear regression			
Predictors	Estimates	CI	*P*-Value
Attended B-Con class	−1.03	−1.27 – −0.79	**<0.001***
Primed to aid	−0.35	−0.57 – −0.12	**0.003***
Visual-audio aid	−0.34	−0.57 – −0.12	**0.002***
Visual aid	−0.05	−0.27 – 0.17	0.650
Age	0.04	−0.05 – 0.12	0.404
Male gender	0.07	−0.11 – 0.26	0.435
Identifying a life-threatening wound for tourniquet placement Multiple logistic regression			
Predictors	Estimates	CI	*P*-Value
Attended B-Con class	1.51	0.82 – 2.81	0.186
Primed to aid	2.85	1.48 – 5.71	**0.002***
Visual-audio aid	3.05	1.66 – 5.74	**<0.001***
Visual aid	1.41	0.79 – 2.51	0.246
Age	1.06	0.84 – 1.34	0.650
Male gender	2.05	1.25 – 3.42	**0.005***
Seconds to tourniquet application Multiple linear regression			
Predictors	Estimates	CI	*P*-Value
Attended B-Con class	−61.33	−75.35 – −47.31	**<0.001***
Primed to aid	19.33	5.71 – 32.96	**0.006***
Visual-audio aid	26.54	13.39 – 39.69	**<0.001***
Visual aid	18.07	4.78 – 31.36	**0.008***
Age	1.20	−3.77 – 6.17	0.636
Male gender	13.76	2.83 – 24.68	**0.014***

Abbreviation: B-Con, Bleeding Control; CI, confidence interval.
*$P < 0.05$.
**$P < 0.001$.

(Median time for VA = 93 s; VIS = 81 s; control = 69 s). However, control participants who did have access to an aid were more likely to call 911 (VA: OR, 6.14; $P < 0.001$; VIS: OR, 2.34; $P = 0.01$), and those with a VA aid were more likely to accurately assess their own safety (VA: OR, 4.05, $P < 0.001$. VIS: OR, 1.41, $P = 0.24$). These data are shown in Table 2.

Survey Results

Survey results were collected at the end of the simulation. Participants who were given a VA or VIS aid reported that they were more likely to step into an emergency situation (VA: OR, 2.51; $P < 0.001$. VIS: OR, 1.72; $P = 0.037$), more confident in their ability to pack wounds (VA: OR, 2.31; $P = 0.001$. VIS: OR, 1.9; $P = 0.012$), and more confident in their ability to use a tourniquet in a real-life situation than those without an aid (VA: OR, 2.08; $P = 0.004$. VIS: OR, 1.76; $P = 0.029$). Participants who attended the B-Con class, and those who were primed were also more comfortable stepping into an emergency situation (B-Con: OR, 4.21; $P < 0.001$. Primed: OR, 3.66; $P < 0.001$), using a tourniquet (B-Con: OR, 7.94; $P = 0.005$. Primed: OR, 3.57; $P < 0.001$), and packing a wound (B-Con: OR, 2.52; $P = 0.005$. Primed: OR, 4.74; $P < 0.001$). Participants who did not have an aid and those who used a VIS aid reported they did not believe an aid would help them at the testing station (No aid: OR, 0.37; $P = 0.014$. VA: OR, 0.24; $P = 0.001$). Those with a VA aid did not have a statistically significant preference (VA: OR, 1.37; $P = 0.35$).

Discussion

Incorporating "just-in-time" audio and visual training in public bleeding control kits is a primary objective of the STB campaign to broaden the scope of knowledgeable laypeople during an active bleeding emergency.[15] However, the type of instructional aids that can provide this training and what specific delivery format is most efficacious remains uncertain, thus providing a barrier to their successful widespread implementation. This study sought to evaluate different cognitive aids provided in varying forms to identify the optimal use of an instructional aid for hemorrhage control skills. We demonstrate stepwise improvements in tourniquet performances in simulated active shooter scenarios when college students (1) attended an in-person bleeding control course, (2) had access to a visual-audio aid, and (3) were primed on that aid before use. Furthermore, we newly demonstrate that wound packing skills may be complemented with a cognitive aid, including in bystanders without any previous training, to comparable levels of those with previous training. Ultimately, while just-in-time cognitive aids may provide a worthy addition to publicly accessible hemorrhage control kits, the type of aid delivered and the format of its use have varying effects on bystander hemorrhage control skills that can be optimized and must be noted.

The specific type of instructional aid, the method of delivery, and how participants are familiarized ("primed") with the aid are essential elements that may influence the efficacy of an aid in an emergency scenario.[6,8,16–18] The current work found that the most optimal format of an instructional aid for tourniquet performance is for bystanders who had attended the B-Con class (OR, 12.67; $P = 9.3 \times 10^{-11}$), used a visual-audio aid (OR, 1.96; $P = 0.04$), and were primed on that aid before using it (OR; 2.23; $P = 0.01$). Specifically, in this format with a visual-audio aid, 77% of laypersons could correctly apply a tourniquet with a third of the number of errors.

Laypersons report the most challenging aspects of tourniquet placement are its technical elements (eg, securing the tourniquet strap and handling the windless rod) rather than basic elements such as determining the correct tourniquet placement location.[6] Thus, a visual-audio aid that walks a bystander through these components step-by-step may be more adequate than a broad visual infographic reading card. However, this study's results were relatively similar between aids (visual-audio 77% vs visual 68%). Participants in our study were encouraged to view the entire aid before testing to gain familiarity with its content. This report did not study the use of such aids in actual emergent situations, leading to the question, "in an emergent situation, would one expect a bystander to stop and review an aid before rendering care?" We can hypothesize that our data demonstrating improved success in tourniquet application through use of an aid may be extrapolated to emergent situations, which we recommend should be further studied through use of high fidelity simulation.[7] We do see the use of instructional aids in bystander CPR[12] as well as with choking episodes, and believe that the hemorrhage control aids studied in this report should be considered in a similar capacity to serve as a refresher to an individual who may have a very high cognitive load when performing a potential life or limb saving procedure with a time constraint.

https://doi.org/10.1017/dmp.2023.92 Published online by Cambridge University Press

Comparatively, when fewer technical steps in a series are necessary for a skill, such as with wound packing and applying pressure, a visual aid may provide superior results due to quickly delivering the key teaching elements (visual-audio 10% vs visual 23%). Interestingly, participants without prior B-Con training who used a visual aid (15%) demonstrated double the wound packing score compared with trained participants using a visual aid without a primer (7%), as well as comparable results to the other previously trained groups. Compared with tourniquet skills, these added benefits for wound packing skills may reflect that the fewer technical steps required for wound packing could be taught with point-of-care instruction in public kits. While the goal of assessing these aids was not to determine the ability to replace B-Con training, these results continue to reflect that adequately constructed aids may provide a beneficial tool for the general public. Furthermore, while not previously examined in this context, if instructional aids are to be included in public kits in the future, it is essential to consider if their efficacy depends on bystanders being familiarized with them during their actual B-Con training.[16] Our results suggest that a 10-min primer during the B-Con course could significantly benefit tourniquet skills regardless of the type of aid used, as shown elsewhere.[16]

Despite the benefits seen from using an aid in varying formats in the current study, attending the B-Con course generally improved hemorrhage control skills in both situational awareness and tourniquet or wound packing performance compared with other groups. This suggests that regardless of having visual or video-audio instruction, an essential aspect of teaching bleeding control skills remains from being able to practice with the tourniquet before testing. While the time between training and testing was purposely kept short in our study and during the same day, increasing the time since training would likely negatively affect bystander hemorrhage control skills upon testing. Previous work suggests a likely critical threshold where skill retention declines at 6 mo, although incorporating an aid can revive these skills.[6–8,18] If this aid is trained on immediately after the completing a technical B-Con course, we hypothesize that retention skills can be further improved by coupling hands-on practice of hemorrhage control skills with cognitive aid familiarity. Future work in this context is necessary moving forward. Given the STB program now offers online instruction as a primary method of training following the coronavirus disease 2019 (COVID-19) pandemic, it will likely become important to have additional tools available to engage bystanders in emergency scenarios should they need it and further augment baseline skills, such as on a mobile application or in a public kit. With either aid available, participants report they were significantly more likely to intervene in an emergency scenario and more confidently pack a wound or apply a tourniquet than if no aid was available to them. Given our performance and survey data on participant confidence in individual steps, this information may be leveraged in future work to improve upon these aids.

Limitations

While the current study sought to be comprehensive on a large cohort of bystanders, it is not without its limitations. Retention of tourniquet placement skills after the B-Con course without further instruction is a concern that has been reiteratively demonstrated previously,[7,8] as well as with wound packing skills recently.[6] Unfortunately, the opportunity to assess skill retention was cut short in the current study, given the onset of the COVID-19 pandemic toward the end of our initial testing phases and the campus-wide cancellation of B-Con training and research activities. While this prevented us from assessing any benefits of these aids on skills at follow-up, this limitation also illustrates the well-known difficulty of the B-Con course—widespread training of bystanders. Thus, while alternative avenues, such as online training and distance learning opportunities, continue to arise, it is vital to implement additional tools that can augment lay rescuer skills in real time and improve their comfortability with these skills or emergency scenarios, as shown in the current study.

Furthermore, our study was limited to college students at a single large institution. While intentional mass casualty scenarios have increased in incidence on college campuses, it is important to consider that these benefits may be less generalizable to the general public of varying age groups and educational backgrounds.

Conclusions

Instructional cognitive aids may provide benefits for point-of-care hemorrhage control skills in bystanders with or without prior training. Adequate tourniquet performance may be improved best with a comprehensive aid including both visual and audio components. In contrast, a visual infographic aid alone may be sufficient to supplement wound packing skills even in non-trained individuals. Ultimately, the optimal method of use for these aids includes bystanders with previous hemorrhage control training and familiarization with the aid before use and, therefore, should be the focus of future widespread incorporation of instructional aids into the B-Con course.

Acknowledgments. Authors of this study thank Michelle Rinaldi for her contribution in illustrating the visual infographic card used in the study. We also thank the White Plains Hospital Simulation Lab, Emily Silver, Kaitlyn Munroe, Daniel Wheeler, and Daisy Gomez for their contribution in organizing the study and collecting data.

Author contribution. Study conception and design: N.B.D & F.N.J.; Data collection: N.B.D, N.H.S, R.C.S.F, J.V.C, K.M.S, M.E.; Statistical Analysis and Interpretation of data N.B.D, F.N.J, B.C, R.C.S.F.; Supplementary Material N.B.D, N.H.S, R.C.S.F.; All authors helped write, review, revise and approve of this manuscript for submission, and publication.

Funding. No funding.

Competing interests. The authors have no potential conflicts of interest to disclose.

References

1. **FBI**. Active shooter incidents in the United States in 2021. Published May 19, 2022. Accessed October 26, 2022. https://www.fbi.gov/filerepository/active-shooter-incidents-in-the-us-2021-052422.pdf
2. **Bulger EM, Gestring ML, Jacobs LM.** Optimizing bleeding control training for the public: a national imperative. *JAMA Surg.* 2018;153(9):799. doi: 10.1001/jamasurg.2018.1100
3. **Jacobs LM, Wade D, McSwain NE, *et al.*** Hartford Consensus: a call to action for THREAT, a medical disaster preparedness concept. *J Am Coll Surg.* 2014;218(3):467-475. doi: 10.1016/j.jamcollsurg.2013.12.009
4. **Goolsby C, Branting A, Ausman J, *et al.*** Systematic review of live tissue versus simulation education for prehospital trauma providers. *Mil Med.* 2017;182(9):e1824-e1833. doi: 10.7205/MILMED-D-17-00026
5. **Eastridge BJ, Holcomb JB, Shackelford S.** Outcomes of traumatic hemorrhagic shock and the epidemiology of preventable death from injury. *Transfusion.* 2019;59(S2):1423-1428. doi: 10.1111/trf.15161
6. **Dadario NB, Felipes RCS, Cooney JV, *et al.*** The impact of a mobile phone application for retention of bleeding control skills. *J Surg Res.* 2021;267:669-677. doi: 10.1016/j.jss.2021.06.021

7. **Jafri FN, Dadario NB, Kumar A, *et al.*** The addition of high-technology into the Stop the Bleed Program among school personnel improves short-term skill application, not long-term retention. *Simul Healthc.* 2021;16(6): e159-e167. doi: 10.1097/SIH.0000000000000546
8. **Goralnick E, Chaudhary MA, McCarty JC, *et al.*** Effectiveness of instructional interventions for hemorrhage control readiness for laypersons in the Public Access and Tourniquet Training Study (PATTS): a randomized clinical trial. *JAMA Surg.* 2018;153(9):791-799. doi: 10.1001/jamasurg.2018.1099
9. **Humar P, Goolsby CA, Forsythe RM, *et al.*** Educating the public on hemorrhage control: methods and challenges of a public health initiative. *Curr Surg Rep.* 2020;8(5):1-7. doi: 10.1007/s40137-020-00252-8
10. **Goolsby C, Rojas LE, Rodzik RH, *et al.*** High-school students can stop the bleed: a randomized, controlled educational trial. *Acad Pediatr.* 2021; 21(2):321-328. doi: 10.1016/j.acap.2020.05.012
11. **Weinman S.** Retention of tourniquet application skills following participation in a bleeding control course. *J Emerg Nurs.* 2020;46(2): 154-162. doi: 10.1016/j.jen.2019.10.020
12. **Chen K-Y, Ko Y-C, Hsieh M-J, *et al.*** Interventions to improve the quality of bystander cardiopulmonary resuscitation: a systematic review. *PLoS One.* 2019;14(2):e0211792. doi: 10.1371/journal.pone.0211792
13. **Schulz KF, Altman DG, Moher D, *et al.*** CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMJ.* 2010;340:c332. Published 2010;340:c332. doi: 10.1136/bmj.c332
14. **Gegel B, Burgert J, Cooley B, *et al.*** The effects of BleedArrest, Celox, and TraumaDex on hemorrhage control in a porcine model. *J Surg Res.* 2010;164(1):e125-e129
15. **JEMS Staff**. What the White House's Stop the Bleed Campaign Means for EMS. Published April 5, 2016. Accessed October 26, 2022. https://www.jems.com/patient-care/trauma/what-the-white-house-s-stop-the-bleed-campaign-means-for-ems/
16. **Zasso FB, Perelman VS, Ye XY, *et al.*** Effects of prior exposure to a visual airway cognitive aid on decision-making in a simulated airway emergency: a randomised controlled study. *Eur J Anaesthesiol.* 2021;38(8):831-838. doi: 10.1097/EJA.0000000000001510
17. **Goolsby C, Branting A, Chen E, *et al.*** Just-in-time to save lives: a pilot study of layperson tourniquet application. *Acad Emerg Med.* 2015;22(9): 1113-1117. doi: 10.1111/acem.12742
18. **Arif A, Santana Felipes RC, Hoxhaj M, *et al.*** The impact of the addition of a virtual reality trainer on skill retention of tourniquet application for hemorrhage control among emergency medical technician students: a pilot study. *Cureus.* 2023;15(1):e34320. doi: 10.7759/cureus.34320

https://doi.org/10.1017/dmp.2023.92 Published online by Cambridge University Press