van Duijn, T., Sabrah, N. Y. A., & Pellegrino, J. L. (2024). Do-It-Yourself Devices for Training CPR in Laypeople: A Scoping Review. *International Journal of First Aid Education*, *7*(1), 1–26. DOI: https://doi.org/10.25894/ijfae.2306

RESEARCH

Do-It-Yourself Devices for Training CPR in Laypeople: A Scoping Review

Tina van Duijn*, Faculty of Health, Human Performance Research Centre, University of Technology Sydney, Australia, tinavanduijn@gmail.com

Nagwa Yehya Ahmed Sabrah, Faculty of Nursing, Mansoura University, Egypt, nagwayehya@mans.edu.eg

Jeffrey L. Pellegrino, School of Disaster Science & Emergency Services, University of Akron, Ohio, USA, jpellegrino@uakron.edu

*Corresponding author

ABSTRACT

Background: Layperson cardiopulmonary resuscitation (CPR) is an important skill with the potential to save millions of lives. However, CPR courses often require commercial, complicated, and expensive manikins. To increase access to CPR training worldwide at very low costs, Do-It-Yourself (DIY) devices may be a suitable tool for practising compressions.

Objective: This scoping review is the first step in scoping and mapping the evidence on the effectiveness of DIY devices for laypersons learning adult CPR, along with defining gaps for future research.

Method: This inquiry was structured by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines. A systematic search of 14 academic databases and popular media archives, with additional hand searches, identified academic reports and resources describing DIY

Submitted: 23 October 2023 **Accepted:** 02 March 2024 **Published:** 21 March 2024

compression device construction and/or implementation. Research studies were synthesized narratively, and the main characteristics of all resources were presented in a table.

Results: Fifteen studies compared learning outcomes of CPR practice either pre-post DIY practice or between DIY and commercial manikins. Studies varied in the intervention (e.g., learning modality, time, manikin) and measurement, which precluded formal meta-analysis. Of the 55 different DIY devices described throughout all resources, 26 (47.3%) used plastic bottles for compression practice. Analysis of the resources revealed gaps in the current evidence base, such as a lack of clear assessment criteria, standardized procedures for comparisons, and sociocultural questions.

Conclusion: This scoping review has identified a small number of studies which described different DIY devices for learning basic CPR skills to different extents. While there is a need for a more comprehensive search and full systematic review, the findings serve as a starting point for future investigations and support evidence-based choices regarding DIY manikins for teaching adult CPR.

Keywords: Training; Cardiopulmonary Resuscitation; CPR; Manikin; Handmade; Do-it-Yourself; First Aid Education

ABSTRAITE

Introduction: La réanimation cardiopulmonaire (RCP) est une compétence vitale qui peut sauver des vies, mais son apprentissage peut être entravé par le coût et la complexité des équipements commerciaux. Pour rendre la formation de la RCP plus accessible à travers le monde, des appareils fait à main (DIY) pourraient représenter une solution abordable et pratique.

Objectif: Cette revue evalue l'efficacité des appareils DIY pour la formation de RCP pour non-specialistes, et identifie les manques de recherche.

Méthode: Nous avons suivi les directives de PRISMA-ScR pour structurer notre recherche. Une analyse approfondie de 14 bases de données académiques et d'archives médiatiques a permis d'identifier des ressources décrivant la construction et l'utilisation d' appareils DIY pour pratiquer la RCP. Les résultats ont été synthétisés de manière narrative et les caractéristiques principales des dispositifs ont été présentées dans un tableau.

Résultats: Nous avons identifié 15 études comparant les résultats d'apprentissage de la RCP avant et après l'utilisation de dispositifs DIY, ainsi que par rapport aux mannequins commerciaux. Les appareils DIY variaient largement, par exemple 26 sur 55 utilisaient des bouteilles en plastique pour la pratique des compressions. Notre analyse a révélé des lacunes dans les critères d'évaluation, dans les procédures standardisées, ainsi que des questions socioculturelles non résolues.

Conclusion: Malgré le nombre limité d'études disponibles, notre revue souligne le potentiel des dispositifs DIY pour l'apprentissage de la RCP. Des recherches supplémentaires sont nécessaires pour combler les lacunes identifiées, mais ces premières conclusions ouvrent la voie à des choix éclairés dans l'utilisation de mannequins DIY pour enseigner la RCP aux non-specialistes.

Mots-clés: Formation; Education; Réanimation Cardiopulmonaire; RCP; Mannequin; Fait à main; DIY; Bricolage; Formation de Premiers Secours

ABSTRACT

الخلفية: يعد الإنعاش القلبي الرئوي من قبل العامة مهارة مهمة لها القدرة على إنقاذ ملايين الحيوات. ومع ذلك، فغالبًا ما تتطلب دورات الإنعاش القلبي الرئوي دمى تجارية ومعقدة وباهظة الثمن. ولزيادة الوصول إلى التدريب على الإنعاش القلبي الرئوي في جميع أنحاء العالم بتكاليف منخفضة للغاية، فقد تكون أجهزة "افعلها بنفسك" أداة مناسبة لممارسة الضغطات.

الهدف: يعد هذا المرجع واسع النطاق هو الخطوة الأولى في تحديد ورسم الدليل حول فعالية أجهزة "افعلها بنفسك" للعامة الذين يتعلمون الإنعاش القلبي الرئوي للمصابين البالغين، إلى جانب تحديد الثغرات للبحث المستقبلي.

الطريقة: تم تنظيم هذا المرجع بولسطة عناصر ارشادية مفضلة للمراجع المنهجية والتحليلات الوصفية للمراجع النطاقية (PRISMA-ScR). فمن خلال عمل بحث منهجي لعدد 14 قاعدة بيانات أكاديمية وأرشيفات إعلامية عامة، بالاضافة الي البحث اليدوي، فقد تم تحديد التقارير الأكاديمية والمصادر التي تصف إنشاء جهاز ضغط "افعلها بنفسك" و/أو تنفيذه. وتم تجميع الدراسات البحثية بطريقة سردية، وتم عرض الخصائص الرئيسية لجميع الموارد من خلال جدول.

النتائج: تمت مقارنة مخرجات التعلم لأداء الإنعاش القلبي الرئوي من خلال خمسة عشرة دراسة إما قبل وبعد الأداء باستخدام جهاز "افعلها بنفسك" أو بين جهاز "افعلها بنفسك" والدمي التجارية. لقد تنوعت الدراسات من حيث التدخل (على سبيل المثال، طريقة التعلم، والوقت، والدمي) والقياس والذي تضمن التحليل الوصفي الرسمي. فمن بين 55 جهازًا مختلفًا تم وصفه في جميع المصادر، تم استخدم 26 (47.3%) زجاجات بلاستيكية لممارسة الضغطات. وقد كشف تحليل المصادر عن ثغرات في الدليل الحالي مثل عدم وجود معايير تقييم واضحة، وإجراءات موحدة للمقارنات، والتساؤلات الاجتماعية والثقافية.

الاستنتاج: هذا المرجع النطاقي حدد عددًا صغيرًا من الدراسات التي وصفت أجهزة "افعلها بنفسك" المختلفة لتعلم مهارات الإنعاش القلبي الرئوي الأساسية بدرجات مختلفة. في حين أن هناك حاجة لإجراء بحث أكثر شمولاً ومراجعة منهجية كاملة، فإن النتائج تكون بمثابة نقطة انطلاق للتفحوصات المستقبلية ودعم الخيارات القائمة على الأدلة فيما يتعلق بأشكال الدمى "افعلها بنفسك" لتعليم الإنعاش القلبي الرئوي للبالغين.

الكلمات المفتاحية: التدريب، الإنعاش القلبي الرئوي، الدمى، صناعة يدوية، افعلها بنفسك، تعليم الإسعافات الأولية

For people in cardiac arrest, Cardiopulmonary Resuscitation (CPR) is vital for sustaining blood circulation while awaiting advanced care. CPR competencies encompass affective (stress management), cognitive (assessment of hazard and cardiac arrest signs), and psychomotor (chest compressions, rescue breaths) skills (Greif et al., 2020; International Federation of Red Cross Red Crescent Societies, 2020; Olasveengen et al., 2020). Laypersons' CPR training develops and enhances their competencies, confidence, and willingness to act in an emergency. Chest compression-only CPR (i.e., no ventilation) further simplifies training to boost bystander response rates (Bhanji et al., 2015; Schroeder et al., 2023; SOS-KANTO study group, 2007). CPR education usually comes from recognized providers (e.g., Red Cross/Red Crescent, military service, workplace, and schools) and is promoted through a system of policy and requirements for healthcare personnel as well as lay people (i.e., people who are not trained health care workers, Birkun et al., 2021).

Commercial, in-person CPR training is often costly and time-intensive, impacting accessibility (Cariou & Pelaccia, 2017; Iil Dwi Lactona, 2021; Potts & Lynch, 2006). Disparity also exists between high and low-income regions due to resource availability. Statistics suggest that roughly twice as many people in high-income countries receive CPR training compared to low-income countries (Birkun et al., 2021). Additionally, the COVID-19 pandemic highlighted the limitations of in-person training, including access and personal safety. The current system's weaknesses affect the equitable distribution of CPR education (Blewer et al., 2017).

While instructor-led training is recommended, the European Resuscitation Council's guidelines for CPR suggest that self-instruction with hands-on practice is an effective alternative (Bhanji et al., 2015). In recent years, alternative strategies to acquire basic CPR skills have included shortened courses (Beskind et al., 2016; Nas et al., 2020; Ohle, Moskalyk, Boissonneault, Bilgasem, et al., 2021), the use of peer educators (Beck et al., 2015; Reder et al., 2006), or remote learning via online instruction, recorded classes, or virtual reality (VR) (Lin et al., 2021; Nas et al., 2020). Extending CPR education outside of required and commercial courses benefits public health by increasing people's awareness, willingness to learn CPR, and CPR competencies. To increase the scope of alternative training methods and to address the issue of commercial manikin availability, low-cost manikins (e.g., inflatable manikins or cardboard kit sets) have been developed and shown to achieve learning and retention of compression motor skills (Jones et al., 2007; Laerdal, n.d.; Roppolo et al., 2007). Grass-roots movements extended this idea and developed a wide variety of Do-It-Yourself (DIY) compression devices, made of inexpensive or reused materials available in the home; the oldest dating back to the early 1960s (Hainfeld, 1966). For examples of DIY compression devices, see Figure 1.

To inform the potential adoption of this idea in practice and to define a trajectory for future research, a clear overview of the current evidence base on DIY compression devices is needed. Therefore, this review aims to describe technical elements that are currently used in DIY devices, narratively present the findings of current research, identify researchable gaps in the evidence base, and provide considerations for future development and implementation. This scoping review is the first step toward describing and building a clearer evidence base for this topic in the future.

METHOD

This scoping review followed the recommended Preferred Reporting Items for Systematic Reviews and Meta-Analysis Extension for Scoping Reviews (PRISMA–ScR) framework

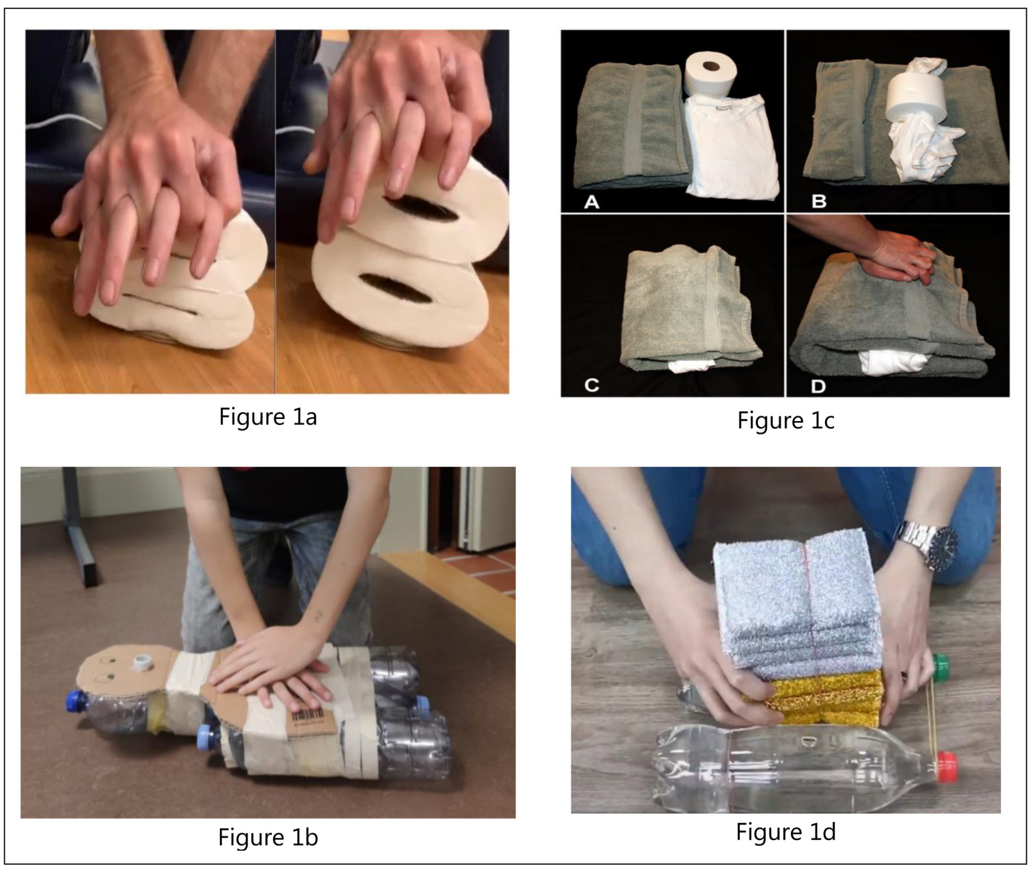

Figure 1: Examples of DIY devices. From top left: a) Ohle et al. (2021) compression tool; b) Szpilman (2019) manikin construction; c) Wanner et al. (2016) compression tool; d): Singapore Heart Foundation (2020) DIY CPR trainer.

(Tricco et al., 2018). The protocols for the review were not previously published. Eligibility criteria, established through consensus amongst the research team, were laypersons receiving adult CPR training and using DIY compression devices. We included peer-reviewed evidence and additional publicly available resources including abstracts, opinion pieces, and instructional videos to better capture the scope of available information, with no date limit. All databases searched used English terms, see Supplementary file. Scoping reviews, infant/neonatal CPR education, and resources above the lay responder level were excluded from the analysis. Search strings, developed with a reference librarian, were used in PubMed, Web of Science, CINAHL, VIRGO Articles, Academic Search Complete, LILACS, Europe PMC, ClinicalTrials.gov, and Google Scholar to diversify the search (Haddaway et. al., 2015). Grey literature searches covered Google, Google Images, YouTube, Reddit, Twitter, and Instagram. After establishing selection criteria through an iterative process (i.e., adapting selection criteria and re-running the selection after initial review) academic and grey literature resources were screened using Rayyan (Ouzzani et al., 2016). To increase consistency amongst reviewers and to norm the process, all reviewers screened the first 15 publications and discussed the results. Reviewers subsequently evaluated the titles and abstracts independently, with a minimum of two reviewers per item, and a discussion was conducted in cases of selection disagreement. A total of 298 articles and 42 other resources (i.e., grey literature) were initially identified, with 14 more identified through hand searches. After screening, 17 peer-reviewed studies (two of which were secondary reports of an already-charted study) and 42 other resources met the inclusion criteria (see Figure 2). Three researchers independently charted the 59 sources based on the media type, peer review status, inquiry type, inclusion of building instructions, and physical components of the DIY device.

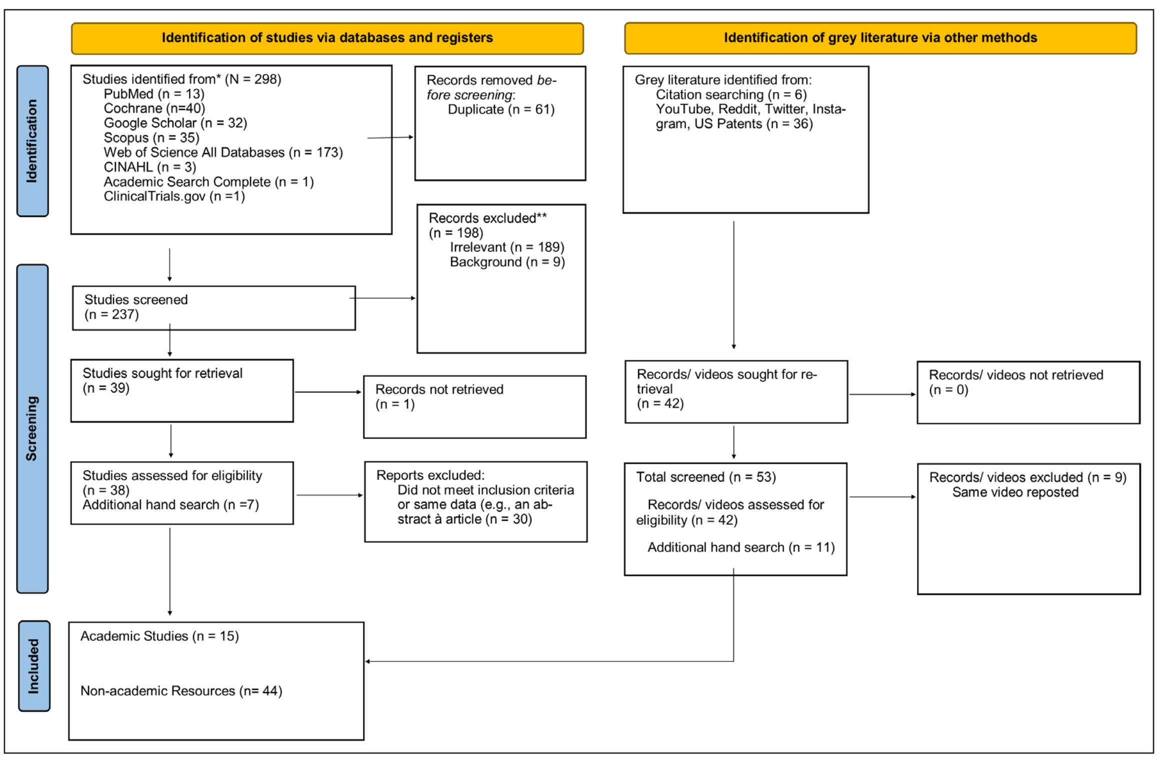

Figure 2: PRISMA 2020 Flow Diagram for New Systematic Reviews Which Included Searches of Databases, Registers, and Other Sources.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/.

RESULTS

Table 1 presents the charted information on the identified resources. We first summarize the scope of current research on the effectiveness of DIY compression devices, before describing the grey literature resources in terms of the physical characteristics of the portrayed DIY devices.

Summary of Scientific Evidence

Out of the 15 studies, three implemented the use of a humanoid-like compression tool (i.e., with a head and torso), three constructed a torso only, and seven used devices that did not have a clearly defined torso or head as illustrated in Figure 1. Two additional studies were

Author/Organization	Country & Resource setting	Media Type	Peer Reviewed	Type of Inquiry	Instruction for Building	Compression Device	Container	Filling
Bonizzio et al. (2019)	Brazil HRS	Academic	P	Observational	Y	PET Bottle	Clothing	Non-fabric
Brush up on EMS (2020)	USA LRS	Video	–	Opinion	Y	Pillow and PET Bottle	Clothing	Fabric
Brush up on EMS (2020)	USA LRS	Video	–	Opinion	Y	Pillow and PET Bottle	Clothing	Fabric
Burckes (1985)	USA LRS	Popular	–	Opinion	Y	Pillow	Clothing	Fabric
Chau et al. (2019)	China LRS	Academic-Augmentation	P	Opinion	Y	–	–	–
Disque foundation (2019)	USA HRS	Video	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
Djajadiningrat et al. (2016)	Netherlands HRS	Academic-Augmentation	P	Project description	N	–	–	–
Don't buy it, I can make that (2013)	USA LRS	Popular	–	Opinion	Y	Plunger	–	–
Drajer (2011)	Argentina LRS	Academic	P	Opinion	Y	Spring	Non-clothing	Non-fabric
Eric Paredes Foundation (2023)	USA HRS	Popular	–	Opinion	Y	Toilet Paper Roll	Non-clothing	Fabric
Goldstein et al. (2018)	USA LRS	Academic	P	Experimental	N	Pillow	–	–
Goldstein et al. (2019)	USA LRS	Academic	P	Experimental	N	Pillow	–	–
Gozuen, et. al., (2020)	Brazil LRS	Academic	P	Observational	Y	PET Bottle	Clothing	Non-fabric
Grand Junction Fire Dept (2022)	USA HRS	Video	–	Opinion	Y	PET Bottle	Clothing	Fabric
Grupo Salvando Vidas (2022)	Mexico	Video	–	Opinion	Y	Jerry can	–	–

(Contd.)

Author/Organization	Country & Resource setting	Media Type	Peer Reviewed	Type of Inquiry	Instruction for Building	Compression Device	Container	Filling
Health & Safety Solutions (2020)	United Arab Emirates	Video	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
Ihenz (2022)	Philippines LRS	Video	–	Opinion	Y	Jerry can	Clothing	–
Lamboy & Donohue (2015)	USA LRS	Academic-Augmentation	P	Opinion	N	–	–	–
Lausa (2021)	Philippines LRS	Video	–	Opinion	Y	Pillow	Clothing	Fabric
Lavoie (2021)		Video	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
Life Saving Victoria (n.d.)	Australia HRS	Popular	–	Opinion	Y	PET Bottle	Clothing	Fabric
Marrodán (2022)	Spain HRS	Video	–	Opinion	Y	Jerry can	Clothing	Non-fabric
Masut (2015)	Argentina LRS	Video	–	Opinion	Y	Rolled-up foam mat	–	–
Masut (2013)	Argentina LRS	Video	–	Opinion	Y	Rolled-up foam mat	–	–
McGinnis (2000)	USA HRS	Popular	–	Opinion	Y	PET Bottle	Non-clothing	Non-fabric
Montalban (2021)	Philippines LRS	Video	–	Opinion	Y	Foam	Non-clothing	Fabric
Nakagawa (2021)	Brazil LRS	Academic	P	Experimental	N	PET Bottle	Non-clothing	Non-fabric
Nas et al. (2020)	Netherlands HRS	Academic-Augmentation	P	Experimental	N	Pillow	–	–
Nas et al. (2021)	Netherlands HRS	Academic-Augmentation	P	Experimental	N	Pillow	–	–
Noko O (2021)	USA LRS	Video	–	Opinion	Y	PET Bottle	Clothing	Fabric
Nolan (2020)	USA LRS	Video	–	Opinion	Y	Toilet Paper Roll	Clothing	Fabric
Ohle, Moskalyk, Boissonneault, Simmons, et. al., (2021)	Canada HRS	Academic	–	Opinion	Y	Toilet Paper Roll	–	–
Ohle, Moskalyk, Boissonneault, Bilgasem, et. al., (2021)	Canada LRS	Academic	P	Experimental	Y	Toilet Paper Roll	–	–

(Contd.)

Author/Organization	Country & Resource setting	Media Type	Peer Reviewed	Type of Inquiry	Instruction for Building	Compression Device	Container	Filling
Parent Heart Watch (2023)	USA LRS	Popular	–	Opinion	Y	Toilet Paper Roll	–	–
Pevida (2022)	Philippines LRS	Video	–	Opinion	Y	Foam	Clothing	Fabric
Pillow CPR (n.d.)	USA HRS	Video	–	Opinion	Y	Pillow	–	–
Piscopo, Piscopo, Fonseca, et al. (2018a) [Duplicate report- Piscopo, Piscopo, Avezum, et. all., (2018)]	Brazil LRS	Academic	?	Experimental	N	PET Bottle	Clothing	Non-fabric
Piscopo, Piscopo, Fonseca, et al. (2018b)	Brazil LRS	Academic	?	Experimental	N	PET Bottle	Clothing	Non-fabric
Piscopo, Piscopo, de Oliveira, et al., (2018)	Brazil LRS	Academic	?	Experimental	N	PET Bottle	Clothing	Non-fabric
Rice (1985)	USA HRS	Popular	–	Opinion	Y	Foam and Balloon	Non-clothing	Non-fabric
Russell (2020)	USA HRS	Video	–	Opinion	Y	Blanket in a cardboard box	Clothing	Fabric
Shafiq (2022)	United Kingdom LRS	Academic	P	Opinion	Y	Pillow	Non-clothing	Fabric
Simple Kits (2022)	Philippines LRS	Video	–	Opinion	Y	Jerry can	Clothing	–
Singapore Heart Foundation (2020)	Singapore HRS	Video	–	Opinion	Y	Toilet Paper Roll	Non-clothing	–
Sociedade de Cardiologia do Estado de SP (2015)	Brazil LRS	Video	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
South Western Ambulance (2020)	United Kingdom HRS	Video	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
Spokane Parks & Recreation (2020)	USA LRS	Video	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
Supa (2021)	Philippines LRS	Video	–	Opinion	Y	Pillow	Clothing	–
Szpilman et al. (2019)	Brazil LRS	Video	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
Tanaka et al. (2017)	Singapore LRS	Academic	P	Experimental	N	Foam	–	–

(Contd.)

Author/Organization	Country & Resource setting	Media Type	Peer Reviewed	Type of Inquiry	Instruction for Building	Compression Device	Container	Filling
Unknown (n.d.)	Sweden HRS	Popular	–	Opinion	Y	PET Bottle	Clothing	Fabric
Van Raemdonck et al. (2014) [duplicate report- Van Raemdonck, et al. (2010)	Belgium LRS	Academic	P	Experimental	N	Foam	–	–
Wanner, Berray, & Osborne. (2016)	USA HRS	Video	–	Opinion	Y	Toilet Paper Roll	Non-clothing	Fabric
Wanner Osborne, & Greene (2016)	USA HRS	Academic	P	Observational	Y	Toilet Paper Roll	Non-clothing	Fabric
Whitehead (2021)	Canada HRS	Video	–	Opinion	Y	PET Bottle	Clothing	Fabric
Wijaya, et. al. (2023)	Indonesia HRS	Academic	P	Experimental	Y	Pillow	–	–
YMCA Aquatics (2023)	USA HRS	Popular-Augmentation	–	Opinion	Y	–	–	–
Youth Heart Watch Philadelphia (2020)	USA LRS	Popular	–	Opinion	Y	PET Bottle	Clothing	Non-fabric
Ypil (2021)	Philippines LRS	Video	–	Opinion	Y	Foam	Clothing	Fabric

Table 1 Initial Categorization of Sources.

Abbreviations: HRS- High Resource Setting; LRS- Low Resource Setting.

augmentations for existing compression devices. Nakagawa et al. (2021) compared the educational outcomes of CPR training with a commercial manikin (Szpilman et al., 2019) against those of a shortened training course with a DIY manikin within school communities in Brazil (n = 1,977). They observed that overall CPR skills were learned to a similar extent in both groups; however, assessing the victim's responsiveness and calling for help were better learned during the extended education course. In a series of conference abstracts and an unpublished manuscript, Piscopo and colleagues described the use of a low-fidelity manikin made by school-age children who stuffed a T-shirt with a PET bottle and filler materials (Piscopo, Piscopo, Avezum, et al., 2018; Piscopo, Piscopo, de Oliveira, et al., 2018; Piscopo, Piscopo, Fonseca, et al., 2018b). In comparison with a commercial manikin, learners performed similarly post-CPR education, except for a trend towards a higher "variable depth compression" (sic) in the DIY manikin group (p = .077) (Piscopo, Piscopo, Avezum, et al., 2018). A larger study did not detect this difference (Piscopo, Piscopo, Fonseca, et al., 2018b). In an unpublished study, Piscopo, Piscopo, de Oliveira et al. (2018) found a DIY-trained group to be non-inferior in all parameters except correct hand placement. Using the same DIY model to train university students, Gozuen et al. (2020) found that CPR knowledge was improved a month post-intervention. Bonizzio et al. (2019) modified the same manikin design by filling PET bottles with 70% water. Participants' knowledge of CPR behaviors and willingness to act significantly improved in that study.

Ohle, Moskalyk, Boissonneault, Simmons, et. al. (2021) designed a CPR compression trainer using two toilet paper rolls that were stacked on top of a mason jar lid to provide feedback (i.e., a clicking sound when correct compression depth was achieved). This device was compared to a commercial manikin with feedback in a non-inferiority study. The difference in mean overall CPR score was below the non-inferiority margin. Wanner, Osborne, & Greene (2016) used a CPR tool built from a towel wrapped around a toilet paper roll through which a T-shirt is threaded. CPR education with a video and the DIY device led to an increase in compression rate among untrained laypeople. Trained and untrained people claimed a significant increase in comfort when performing chest compressions. The untrained group also significantly increased their willingness to perform chest compressions.

Van Raemdonck, Monsieurs, et al. (2014) described the efficacy of low-cost training strategies using foam dice and plastic bags compared to a commercial manikin, combined with different pedagogies. Six months post-training, no differences between intervention groups in CPR performance were observed. Tanaka et al. (2017) compared untrained laypersons' chest compressions on the Push Heart training model (a heart-shaped foam pad) against the Little Anne manikin. Although fewer participants achieved the recommended depth on the Little Anne, participants preferred it because it was more life-like. Wijaya et al. (2023) found that training on a similar product, a "CPR pillow", improved CPR performance and Goldstein et al. (2019) used a pillowcase printed with chest landmarks for hand position and found that willingness to perform CPR increased significantly, and that compression depth was not negatively affected by replacing a manikin with a pillow (Goldstein et al., 2018). However, Nas et al. (2020) compared a VR educational intervention that included practice on a pillow and a traditional 20-minute instructor-led intervention using a commercial manikin. The VR group was non-inferior in compression rate but inferior in depth. A separate analysis of the same study (Nas et al., 2021) using updated rate and depth showed better compliance with chest compression depth in the VR group. See Table 2 for more details on the scientific studies.

Methodological limitations of scientific studies

Heterogeneity among the studies limits any strong generalization of the findings, as do several methodological limitations. Many studies assumed that their participants were starting with equal and low skill levels and did not include any pre-tests (Nakagawa et al., 2021; Ohle, Moskalyk, Boissonneault, Bilgasem, et al., 2021; Piscopo, Piscopo, Avezum, et al., 2018; Piscopo, Piscopo, de Oliveira, et al., 2018; Piscopo, Piscopo, Fonseca, et al., 2018b; Van Raemdonck et al., 2014). The only way to detect a permanent change in skill level is the assessment after a delay – however, only two studies included a delayed retention test for skills or attitude (Gozuen et al., 2020; Van Raemdonck et al., 2014). Some studies relied only on a pre-post comparison without including a control group (Bonizzio et al., 2019; Goldstein et al., 2019; Piscopo, Piscopo, de Oliveira, et al., 2018), increasing the risk of false positives.

Further limitations included the comparison of two intervention groups that were not controlled for demographic variables (e.g., Wanner Osborne, & Greene, 2016) and the use of different intervention protocols between the groups (e.g., Nakagawa, 2021). Non-inferiority studies rely on arbitrary margins, which need to be described clearly in the context of the existing literature (Piscopo, Piscopo, de Oliveira, et al., 2018). Furthermore, many studies assessed skills via outputs from high-fidelity manikin software, for which the underlying calculations are unclear, and which are not validated to our knowledge. In several studies, selection bias was noted concerning participant recruitment, leading to a sample that is not representative of the larger population, see Bonizzio et al. (2019) and Gozuen et al. (2020) as examples. None of the studies assessed rescue breath skills.

Instruction Tutorials for Building DIY Devices

We categorized 55 DIY compression devices used in 59 academic and grey literature resources based on their construction features (excluding four resources that only presented augmentations, see Table 1). The compression element of the manikin, which is responsible for the necessary stiffness and recoil was most commonly a PET bottle/jerry can (n = 26). These bottles varied in size from fuel containers (20 l) to soda bottles (1–1.5 l) taped together for a compression surface, while keeping their caps on to allow for recoil. Materials could generally be acquired in regular home or school settings.

Author (Year), Funding source (if any)	Design	Participants	Intervention	Main outcome measures	Key Findings
Bonizzio et al. (2019)	Pre-post comparison	Remote Community Total n = 96 • Lay people n = 69 • Health professionals n = 17 • Health students n = 10	CPR instruction session during three 1.5h periods of the same day, using a DIY manikin (PET bottle inside a T-shirt) (No control)	Pre- and post-practice CPR-related knowledge Based on: Quiz with MC and open questions	Improvement in overall knowledge (mean pre: 62.7%, mean post: 75.8%, $p < 0.01$), Especially in the concepts related to correct technique. The concepts of "identifying an emergency" and "role of chest compression" showed no statistically significant difference in learning.
Goldstein et al. (2018)	Randomized trial	University Students Total n = 242 • Pillow n = 119 • Manikin n = 123	2-min training intervention with video demonstration and practice-while-watching, using a pillow Control: same video, using a manikin torso.	Post-training performance: Compression rate and depth Based on: manikin software (QCPR).	The control group had a significantly higher compression rate, exceeding recommendations. No significant difference between compression depth (both groups below the guidelines) or overall CPR competency.
Goldstein et al. (2019)	Pre-post comparison	University Students Total n = 360	Training intervention with demonstration and practice on a pillow (No control)	Pre- and post-training: CPR knowledge, willingness to perform CPR, confidence in ability, and likeliness to practice in the next year. Based on: multiple-choice questions, five-point Likert scale questions.	Knowledge of compression depth increased by 47%; knowledge of rate increased by 52%. Significant improvements in all attitude measures (improvements by 20–45%).
Gozuen et al. (2020)	Pre-post comparison	University Students Total n = 44	CPR instruction session using a DIY manikin (PET bottle inside a T-shirt) (No control)	Pre-and post-training knowledge of cardiac arrest & CPR Based on: Questionnaire	Knowledge of cardiac arrest and CPR increased in a 30-day post-intervention survey. Knowledge of CPR skills was higher, but general knowledge of cardiac arrest did not achieve the same growth.

(Contd.)

Author (Year), Funding source (if any)	Design	Participants	Intervention	Main outcome measures	Key Findings
Nakagawa (2021) **Funders:** Fundacao de Amparo a Pesquisa do Estado de Sao Paulo, Programa Aprender na Comunidade	Prospective Cohort Study	People in school communities with no prior CPR training. Total n = 1977 • Intervention group n = 1'630, note: age M = 16 y • Control group n = 347, age M = 27 y	Intervention group: 40-minute program using a DIY manikin (Szpilman model). Control group:120- minute program using Laerdal Little Anne.	Post-training performance: COSB behaviors, compression effectiveness (hand placement, depth, rate, release). Based on: Instructor ratings (Yes or No)	Both programs were effective at improving overall CPR knowledge, skills, and attitudes for ≥89% of school communities. Results were independent of gender, but age played a role in compression depth outcomes (lower depth in young children). The success rate of both programs increased as the age advanced.
Nas, et al. (2020) **Funders:** Zoll, Samsung, Laerdal Medical, Zeiss	Randomized controlled non-inferiority trial	Adult attendees at a music festival, randomized. Total n = 381 • VR training app group: n = 190 • Control group: n = 191	VR group: 20minute intervention using a Virtual Reality (VR) smartphone app. with practice on a pillow Control group: 20-minute face-to-face training with the instructor, and practice on Laerdal Little Anne	Post-training performance: Rate, depth, and total number of compressions, hand position, hands-off time. Based on: manikin software (QCPR).	The group that used VR performed worse regarding chest compression depth but was non-inferior in terms of compression rate. Median CPR performance, average chest compression depth within guidelines, and fraction were all significantly higher in the control group.
Nas, et al. (2021) **Funders:** Zoll, Samsung, Laerdal Medical, Zeiss	Randomized controlled non-inferiority trial- Post Hoc Analysis	Adult attendees at a music festival, randomized. Total n = 381 • VR training app group: n = 190 • Control group: n = 191	VR group: 20minute intervention using a Virtual Reality (VR) smartphone app. with practice on a pillow Control group: 20-minute face-to-face training with the instructor, and practice on Laerdal Little Anne	Post-training performance: Rate, depth, and total number of compressions, hand position, hands-off time. Based on: manikin software (QCPR).	VR training, although previously found inferior to face-to-face, may lead to CPR compliance with recently proposed quality criteria.

(Contd.)

Author (Year), Funding source (if any)	**Design**	**Participants**	**Intervention**	**Main outcome measures**	**Key Findings**
Ohle, Moskalyk, Boissonneault, Bilgasem, et. al., (2021) **Funder:** Northern Ontario Academic Medicine Association	Randomized controlled trial	Visitors to a science center age M = 26.4 y, randomized. Total n = 125 • DIY group n = 64 • Commercial manikin group n = 61	DIY group: 10-minute practice session (including one-on-one demonstration), using a toilet paper trainer with a jar lid. Control group: the same training using a Laerdal Mini Anne trainer.	Post-training overall CPR score, willingness to perform CPR on a stranger and a family member. Based on: manikin software (QCPR), questionnaire.	Overall CPR scores were 2% lower in the DIY group, which was classed as non-inferior. Similar proportions of participants achieved an adequate compression rate. Adequate depth was reached more often after practice with the DIY tool but alongside lower rates of adequate recoil. Willingness to perform CPR on a stranger was higher in the DIY group, but there was no difference in willingness to perform CPR on a family member.
Piscopo, Piscopo, Fonseca et al. (2018a) ***[Duplicate report of Piscopo, Piscopo, Avezum, et al. (2018)]***	Randomized controlled trial	High School students, age M = 14 y, randomized Total n = 88 • DIY group: n = 48 • Control group: n = 40	DIY group: 60-minute training with instruction, using a plastic bottle manikin. Control group: the same training using a Laerdal Little Anne trainer.	Post-training performance: Rate, depth, and total number of compressions, hand position, hands-off time. Based on: Blinded instructor ratings and manikin software (QCPR).	The variability in depth of compression was significantly higher in the DIY group, but no significant group effect on compression depth or any other variables.
Piscopo, Piscopo, Fonseca et al. (2018b)	Randomized trial	Students and teachers from invited schools, randomized Total n = 544 No further detail on group allocation	Intervention group: instruction via video and a 20-min mass training intervention, using a DIY manikin (PET bottle in a T-shirt). Control group: the same intervention using a Laerdal Little Anne manikin.	Post-training performance: hand position, rate, depth, number of compressions, and hands-off time Based on unclear, the assumption is QCPR	No significant differences between the two groups for any variables.

(Contd.)

Author (Year), Funding source (if any)	Design	Participants	Intervention	Main outcome measures	Key Findings
Piscopo, Piscopo, de Oliveira, et al. (2018)	Randomized controlled noninferiority trial	Students at public schools, over 12 years old, randomized Total n = 1324 • DIY group: n = 667 • Control group: n = 666	DIY group: 40-minute training intervention with instructions and using recyclable PET-bottle manikin. Control group: the same training using Laerdal Mini Anne.	Post-practice QCPR scores Based on: manikin software (QCPR).	No significant difference between the two groups after training. Participants showed the same effectiveness in the "step-by-step" and similar quality of chest compressions.
Tanaka et al. (2017)	Prospective crossover study	Laypeople attending a CPR course, randomized Total n = 42 Groups crossed over; thus within-subject comparisons were made.	Intervention group: continuous chest compression practice for 2 minutes using a "Push Heart" (i.e., a foam block) Control group: continuous chest compression practice for 2 minutes using a Laerdal Little Anne manikin.	Within-subject comparisons: Compression depth, rate (using blinded CPR cards). Preference and rating of preparedness (via survey).	The average compression depth and percentage of people who reached adequate depth were significantly higher when performing compressions on the commercial manikin. Participants reported being well-prepared with either model, median score of 8/10 on the commercial manikin compared to 7/10 on the DIY, which was significantly different. The majority of participants, especially the elderly, had difficulty achieving adequate depth.
Van Raemdonck, Monsieurs, et al. (2014) ***[Duplicate report of Van Raemdonck, V., Monsieurs, K. G., & De Martelaer, K. (2010)*** **Funder:** Research Fund of Erasmus University College Brussels	Randomized controlled trial	School children (15–16 years), randomized Total n = 593 • CPR manikin + video instruction (n = 146) • Foam dice + teacher instruction (n = 155) • Foam dice + video instruction (n = 149) • Control group: CPR manikin + teacher instruction (n = 143)	50- min learning course standardized in duration, hands-on time (6 min), and pupil-manikin or pupil-dice ratio (4: 1) The course differed between 4 groups in compression tool used (DIY foam dice vs. commercial manikin) and instruction method (video vs. teacher instruction).	Post-practice performance and 6-month retention: compression depth, rate, quartiles of compressions with correct hand position, correct compressions and mean ventilation volume. Based on: manikin software (QCPR).	No significant differences in long-term learning outcomes based on equipment. The use of alternative equipment resulted in small differences in short-term learning outcomes in compression quality, depth, and hand position, but these differences disappeared after 6 months. After 6 months, a quarter of all participants retained the correct compression depth.

(Contd.)

Author (Year), Funding source (if any)	Design	Participants	Intervention	Main outcome measures	Key Findings
Wanner et al. (2016) **Funders:** AMA Foundation Seed Grant Research Program, Laerdal Medical	Parallel-design study	Volunteers Total n = 24 • Never-trained n = 12 • Certified n = 12	6-minute training video and practice with DIY tool (T-shirt threaded through a toilet roll, wrapped in a towel). (No control)	Pre-post comparison Compression rate, depth, and recoil Based on: Sensor-equipped CPR manikin ("Skill-reporter"), corroborated by ratings from 2 blinded experts.	Untrained group: Significant improvements in compression rate, hand position, recoil, and hands-off time. Certified group: Adequate compression rates before and after training, significant improvements in the percentage of compressions with the correct release, hands-off time, and time to first compression. Compression depth remained inadequate (<50 mm) in both groups.
Wijaya et al. (2023) **Funder:** Poltekkes Kemenkes Palembang	Pre-post comparison	BLS trained volunteers Total n = 40	The intervention included practice with a CPR Pillow, but the duration and instructions were unclear. (No control)	Pre-post comparison Performance-based on CPR Operational Procedure checklist. Likert scale-type expert assessment of CPR Pillow: design, thickness, instructions, and whether it enables compressions.	Significant improvement in CPR skills. The expert assessment found the design, thickness, instructions, and promotion of compressions as "good" (i.e., best possible rating)

Table 2: Characteristics and Outcomes of Experimental Studies.

Abbreviations: n- Number, CPR-Cardiopulmonary Resuscitation, DIY- Do-It-Yourself, PET- Polyethylene Terephthalate, MC-Multichoice, COSB-Chain of Survival Behaviors, M-Mean, VR-Virtual Reality, QCPR-Quality-CPR (a type of feedback software).

Of the 45 non-academic resources, 60% used clothing as a container for the compression element to represent a human chest. The cavity around the compression device was filled with other clothing, plastic bags, and Styrofoam pieces. Head apparatus options included balloons, cardboard, inflatable balls, and stuffed animals often lodged in the hood of a sweatshirt (or hoodie). The remainder of the compression devices were wrapped in towels, placed in boxes, or were not covered (e.g., pillows or foam blocks).

Nine non-academic DIY models didn't have a human form (i.e., simply the compression device), 15 had just a torso, 18 had a head and torso represented, and three included arms, legs, and head. Outside of compression skill practice, seven contributions addressed the skill of ventilation.

Quality of the Grey Literature

The academic quality of the grey literature was very low, as the resources came from popular media, often representing opinions without reference to any standard or set of criteria. Several contributions gained face validity by being associated with health organizations by their creators, but only a few appeared to be endorsed by the organization (Disque Foundation, 2019; Eric Paredes Foundation, 2023; Grand Junction Fire Department, 2022; Singapore Heart Foundation, 2020). Most of the identified resources provided information on how to build the manikin but reporting generally lacked information on volume or dimensions. Many of the instructional videos included further explanations of how to practice CPR.

DISCUSSION

We sought to describe the educational and practical attributes of DIY manikins, from 15 studies of varying quality comparing the outcomes of compressions by learners using DIY devices. These studies were heterogeneous regarding physical design, recording devices, and educational intervention (time, content, etc., see Table 2). The total 15 studies investigated a range of factors, including skill components such as compression rate, recoil, compression depth, hand placement and hands-off time, as well as readiness or willingness to act, confidence, knowledge and preferences. The studies investigated different target groups, for example, children in Van Raemdonck De Martelaer, & Aerenhouts' study (2014), adults in Ohle, Moskalyk, Boissonneault, Bilgasem, et. al. (2021) and Wanner Osborne, & Greene (2016), and two unmatched groups of different ages in Nakagawa (2021). Aside from comparing skills, other aspects of first aid performance were assessed in some studies, such as hands-off time, calling for help, and assessing the victim's responsiveness (Gozuen et al., 2020; Wanner, Osborne, & Greene, 2016). These are likely affected by aspects of educational interventions, and not directly linked to manikin type. A further variable investigated in several studies was the willingness to perform CPR on a stranger or family member. Three controlled intervention studies each reported on outcomes for groups trained with DIY compared to commercial manikins (Ohle, Moskalyk, Boissonneault, Bilgasem, et al., 2021; Tanaka et al., 2017; Wanner, Osborne, & Greene, 2016). Further research is needed before any specific recommendations can be made.

CPR training should address specific socioeconomic, racial, and ethnic populations who have historically exhibited lower rates of layperson CPR (Merchant et al., 2020). Virtual CPR courses without hands-on practice do not adequately promote compression skills (Van Raemdonck et al., 2017). DIY manikins may provide a valuable tool to complement video-based or other virtual instruction by allowing practice (Wanner et al., 2016). The existing studies and grey literature presented in the present review show a concerted effort to address barriers to traditional CPR education. In the future, the quality of such need-inspired interventions may be improved by the availability of online resources and evidence-based guidelines.

Recommendations for Research

The present review shows clearly that the evidence base for using DIY compression tools is not sufficient to provide any strong conclusions. The following section maps out research priorities that address this current paucity of evidence.

Research to Establish Benchmarks for DIY Devices

Based on the variety of measurement types, variables, and learning outcomes targeted in the existing studies on DIY devices, we realized that for future research to be consistent, we need to establish a common set of outcomes, outcome measures, and measurement tools. Based on agreed-upon measures, we would anticipate agreement on adequate measurement tools. Extremely precise measurements may not be necessary for studies that focus on other aspects of CPR education, such as readiness to act. All research should be informed by its related field (e.g., public health-survival, medicine-neurological impairment, sociology-motivation to help, education- health awareness).

Research to Compare Manikins

We advocate for DIY device research to follow a Population, Intervention, Comparison, and Outcome (PICO) approach. Firstly, educational interventions should be clearly described in terms of duration, pedagogical approaches, and which CPR skills or behaviors are targeted. Second, intervention studies need to be rigorous and controlled, include pre-tests and ideally be randomized (e.g., if the goal of a study is to compare the effect of using DIY and commercial manikins, the didactic approach needs to be identical across intervention groups). Third, we recommend that anterior-posterior diameter, the force needed to compress the manikin by a certain depth, and the durability be reported. For potential comparisons and outcome measures in future studies, see Table 3.

Research on the Design of Manikins

With no industry standards for the design of CPR manikins, future designs may be based on emerging evidence. Organizations such as the American Red Cross specify required standards in terms of compression depth, lung volume, and feedback (American Red Cross, 2006) but do not specify required resistance or stiffness. Basic research on the attributes of the human body that affect the ideal provision of CPR needs to be conducted and used as a basis for design purposes.

Research in the Public Health Domain

The more people worldwide who can perform early CPR, the higher the survival rate and neurological outcomes of out-of-hospital-cardiac-arrest victims (Geri et al., 2017).

Study focus	**Outcomes Useful for Recommendations**
Between various DIY devices • DIY compression tool and DIY manikin (anthropomorphized) • DIY device and the augmentation of the device	• Time to construct • Cost to construct • Durability of manikin (personal one-time use, class use, multiple learners) • Overall CPR knowledge (immediate & retention) • Specific skill performance (immediate & retention) • Intention to help in an emergency; Intention to perform CPR (immediate & retention)
Between or within various populations • By age/developmental level • CPR educational level • Various occupations	
Pedagogical interventions • Self-directed (asynchronous/virtual) and facilitated use of a device • Time on skill practice • DIY devices with and without passive or active feedback	
Implementation of a CPR training program with DIY devices	• Financial costs, per learner • Time costs, per learner or organization • Health outcomes • Population acceptance

Table 3: Research Opportunities with DIY Devices for CPR Education.

A DIY device may provide better access to CPR education for people with barriers related to disability, cultural or linguistic factors, geographical location, or economic factors, as well as school-age children. Although various populations used or could use DIY devices, there is no population-based evidence. Qualitative research methods may provide insight into factors that determine expected learning outcomes in a population of interest, and how awareness and empowerment may best be achieved in each community, while quantitative research may describe the effects at the population level. Ethically, it is also important to initiate a discussion on whether the promotion of a DIY device for specific target groups might result in alienation.

Research in the Field of CPR Practice

Skill acquisition research may focus on aspects of the learning environment that generally help or hinder successful learning and transfer to real-life contexts. Neither DIY nor commercial devices can likely meet all of a learner's needs (Van Raemdonck et al., 2014). We encourage research directed toward a fuller understanding of factors that motivate and facilitate CPR competencies in all laypeople (Pellegrino & Asselin, 2020) with the introduction of DIY devices.

Research methodology: consideration and reporting of manikin design

This scoping review emphasizes the critical role of DIY manikin design features in understanding study outcomes. To enable appropriate interpretation of the findings and to facilitate informed decision-making by stakeholders, researchers must describe and justify the design of the DIY manikin utilized in their investigations, taking into account the learning objectives and target demographic of the intervention. The following considerations might be a useful tool in this process:

Physical Characteristics: If exact compression skills are an intended learning outcome, it is important to practice on a manikin with realistic stiffness and recoil ability for many repetitions. The exact requirements are not known, but Nysaether et al., (2008) reported that 500 N of force is needed to compress a human chest. Designs that use heavier materials such as plungers, springs, or high-quality foam could be more durable for extended use than lightweight PET bottles or toilet paper rolls (Wanner Osborne, & Greene, 2016). Wanner Osborne, & Greene's (2016) device was modeled on the force needed (35.5 kg) to compress the CPR Anytime kit (AHA, Dallas, TX). This same force compressed their device to 46.6 mm. Mimicking the dampening effect of a human chest may be achieved by placing a pillow under the compression device. These factors are less important when the goal is simply to introduce a learner to the skill – indeed, for children or those with limited body mass, a DIY device that is easily compressed may even increase motivation.

Shape: The psychological fidelity of a simulation (i.e., the degree to which a simulation replicates the perceptual-cognitive demands of the real task (Gray, 2019) influences the effectiveness of a learning intervention (Harris et al., 2020). If a DIY compression device presents as non-humanoid (e.g., made from a towel folded into a square), it is much more difficult to link the device to a human chest, as the two do not look alike. Children especially may struggle to make analogical connections between concepts, as they have a lower ability for abstraction (Gentner & Hoyos, 2017). Similarly, the imitation of a human head and neck would also be advised, especially if the intended skills include airway opening and ventilation. Some suggestions found in the grey literature include using clothes pins for pinching the nose (Ypil, 2021) or plastic bags to represent a lung (Grupo Salvando Vidas, 2022; Masut, 2015). Furthermore, the option to modify or individualize a DIY device with gender or cultural characteristics might improve learning and retention (Moghimi et al., 2016).

Materials: Environmental sustainability can also be addressed when implementing DIY devices: most of the resources advocate for repurposing previously used materials. A wide range of materials allows flexibility between regions while reducing economic barriers. The most expensive option included a smartphone app which may not be accessible in lower-income communities.

Building Process: The time and complexity of constructing a device needs to be appropriate to the learner. Most of the DIY devices required fewer than four steps to build. To introduce CPR in a large group such as a school, an easy-to-build model may be preferred. The process of building the device may also lead to a better understanding of CPR physiology. For example, Barcala et al. (personal communications, 2023) had children build a device during science class, where they concurrently learned about blood flow and the brain.

Inclusion of Ventilation: A clear bias exists in the literature toward compression-only CPR; however, ventilation remains a valuable skill to address in developing a resuscitation system. DIY designs for ventilation practice should allow for ventilation up to 700–1000 ml of air in adult CPR manikins (American Red Cross, 2006) and offer the opportunity to practice manual airway opening maneuvers, see Szpilman (2019), Grupo Salvando Vidas (2022), or Masut (2013, 2015) as examples.

Provision of Feedback: The International Liaison Committee on Resuscitation included a weak recommendation for feedback on compression rate, depth, and hand position during CPR training (Greif et al., 2020). DIY design options for feedback include a jar lid that clicks (Ohle, Moskalyk, Boissonneault, Bilgasem, et al., 2021) and a tapping device (Masut, 2015). Augmentations for DIY devices, such as smartphone apps, may provide visual or auditory feedback (Chau et al., 2019; Lamboy & Donohue, 2015).

Gender Presentation: Racial, ethnic, and gender-related disparities exist in those who receive layperson CPR (Ok Ahn et al., 2023) and CPR education (Greif et al., 2020). A low-cost hack to simulate female breasts is a bisected foam football that can be placed inside a bra to promote comfort and skill (YMCA Aquatics, 2023). An interactive mat printed with a life-sized female figure may also reduce the stress of demonstrating skills on an actual female (Djajadiningrat et al., 2016). Further research is required to test augmentative tools in combination with DIY devices.

Augmentations: Several resources described low-cost augmentations that might further increase the effectiveness of compression devices. Arif et al. (2021) used a mobile app in combination with a pillow to practice compressions. Lamboy and Donohue (2015) showed that practice with a mobile app connected to a manikin provided a fuller CPR experience than without the app. Chau et al. (2019) reported that a wearable device for the wrist that collects objective feedback on compression depth and rate allows learners to share feedback with a trainer at a distance. Studies in which participants compressed a pillow while following a scenario in VR found that although the compression depth was inferior, the compression rate was non-inferior to that of manikin-trained learners (Nas et al., 2020). Combined with further development on DIY device efficacy, technology could render CPR education more accessible.

Limitations

Despite a systematic approach through academic and grey literature searches, several resources were identified outside databases, such as non-English resources or conference presentations, so others may still not be identified here. Additionally, we acknowledge that a (subconsciously) 'Western' perspective may be pervasive in the statement of the problem, search terms, and writing. The issues linked with access to relevant first-aid skills across different cultures are not well understood and may be better addressed with other solutions. Furthermore, the search strings used could not include all possible terms in all languages that might present a similar idea. To address this, we used MeSH headings in PubMed, but we recognize that there still may have been more possible terms (e.g., adding the terms 'basic life support' and 'training device(s)' may have yielded more findings). Resources were not excluded based on publication status, as the COVID-19 pandemic caused recent attention to this research topic, leading to many grey literature resources.

CONCLUSION

This scoping review of the academic and grey literature on DIY compression devices has identified a small number of studies describing different DIY devices for learning basic CPR skills to different extents. There is a need for a more comprehensive search and full systematic review to make statements on their effectiveness. The findings serve as a starting point for future investigations and support evidence-based choices regarding DIY manikins for teaching adult CPR.

ACKNOWLEDGEMENTS

The authors would like to thank Nathan Charlton and the University of Virginia Libraries for organizing the systematic inquiry, Ignacio Ognian of the University of Virginia, and Arnab Roy of the University of Akron, for assisting in the initial screening of resources. We also thank Naomi Kondo Nakagawa and Ana Catarina Queiroga for their early support in organizing the resources. We would further like to thank the Swiss Lifesaving Society for (re-)igniting this research area, and all members of the DIY Manikin Research Network for their valuable input. A platform for interaction, collection, and dissemination of ideas, research, pilot studies, and a continuously updated manikin inventory can be found at https://mymanikins.info/.

FUNDING INFORMATION

This research was partially funded by the Swiss Lifesaving Foundation (SLRG).

COMPETING INTERESTS

JP is an editor for IJFAE and was removed from all editorial discussions relating to the processing of this paper.

AUTHOR AFFILIATIONS

Tina van Duijn
Faculty of Health, Human Performance Research Centre, University of Technology Sydney, Australia
Nagwa Yehya Ahmed Sabrah
Faculty of Nursing, Mansoura University, Egypt
Jeffrey L. Pellegrino orcid.org/0000-0003-3650-158X
School of Disaster Science & Emergency Services, University of Akron, Ohio, USA

REFERENCES

American Red Cross. (2006). *Adult CPR manikin requirements minimum features of adult CPR manikins that are required when conducting American Red Cross First Aid, CPR, and AED certification courses*. https://www.cpr-savers.com/assets/images/pdf/american-red-cross-training-manikin-requirements.pdf

Arif, A., Arif, A., Fasciglione, K. A., & **Jafri, F. N.** (2021). The iterative development and testing of an interactive mobile application for skill retention of cardiopulmonary resuscitation among high school students: A pilot study. *Simulation and Gaming*, *52*(5), 650–663. DOI: https://doi.org/10.1177/10468781211032692

Beck, S., Issleib, M., Daubmann, A., & **Zöllner, C.** (2015). Peer education for BLS-training in schools? Results of a randomized-controlled, noninferiority trial. *Resuscitation*, *94*. DOI: https://doi.org/10.1016/j.resuscitation.2015.06.026

Beskind, D. L., Stolz, U., Thiede, R., Hoyer, R., Burns, W., Brown, J., Ludgate, M., Tiutan, T., Shane, R., McMorrow, D., Pleasants, M., & **Panchal, A. R.** (2016). Viewing a brief chest-compression-only CPR video improves bystander CPR performance and responsiveness in high school students: A cluster randomized trial. *Resuscitation*, *104*, 28–33. DOI: https://doi.org/10.1016/j.resuscitation.2016.03.022

Bhanji, F., Finn, J. C., Lockey, A., Monsieurs, K., Frengley, R., Iwami, T., Lang, E., Ma, M. H.-M., Mancini, M. E., McNeil, M. A., Greif, R., Billi, J. E., Nadkarni, V. M., Bigham, B., Bray, J. E., Breckwoldt, J., Brooks, S. C., Cheng, A., Donoghue, A. J., …, & **Yeung, J.** (2015). Part 8: Education, Implementation, and Teams. *Circulation*, *132*(16_suppl_1), S242–S268. DOI: https://doi.org/10.1161/CIR.0000000000000277

Birkun, A., Gautam, A., & **Trunkwala, F.** (2021). Global prevalence of cardiopulmonary resuscitation training among the general public: a scoping review. *Clin Exp Emerg Med*, *8*(4), 255–267. DOI: https://doi.org/10.15441/ceem.21.066

Blewer, A. L., Ibrahim, S. A., Leary, M., Dutwin, D., McNally, B., Anderson, M. L., Morrison, L. J., Aufderheide, T. P., Daya, M., Idris, A. H., Callaway, C. W., Kudenchuk, P. J., Vilke, G. M., & **Abella, B. S.** (2017). Cardiopulmonary resuscitation training disparities in the United States. *Journal of the American Heart Association*, *6*(5). DOI: https://doi.org/10.1161/JAHA.117.006124

Bonizzio, C. R., Nagao, C. K., Polho, G. B., & **Paes, V. R.** (2019). Basic life support: An accessible tool in layperson training. *Revista Da Associacao Medica Brasileira*, *65*(10), 1300–1307. DOI: https://doi.org/10.1590/1806-9282.65.10.1300

Brush Up On EMS. (2020). *DIY EMS mannequin part 1 [Video]*. YouTube. https://www.youtube.com/watch?v=SwKBAoubITI

Brush up on EMS. (2020). *DIY EMS mannequin part 2 [Video]*. YouTube. https://www.youtube.com/watch?v=_hYXnmmXZEQ%0A

Burckes, M. E. (1985). The improvised manikin–homemade CPR equipment. In *Health education* (Vol. 16, Issue 5, p. 52). American Alliance for Health Physical Education, Recreation and Dance. DOI: https://doi.org/10.1080/00970050.1985.10615880

Cariou, G., & **Pelaccia, T.** (2017). Are they trained? Prevalence, motivations and barriers to CPR training among cohabitants of patients with a coronary disease. *Internal and Emergency Medicine VO – 12*, *6*, 845. DOI: https://doi.org/10.1007/s11739-016-1493-8

Chau, C. H., Hung, K., Ko, C. P., & **Lo, S. F.** (2019). Design and development of a mobile application and wearable system for CPR training. *ICETAS 2019 – 2019 6th IEEE International Conference on Engineering, Technologies and Applied Sciences*. DOI: https://doi.org/10.1109/ICETAS48360.2019.9117566

Disque Foundation. (2019). *How to make DIY CPR manikin at home [Video]*. Nhcps.Com. https://www.pinterest.com/pin/573083121333156710/

Djajadiningrat, T., Lui, P., Chao, P. Y., & **Richard, C.** (2016). Virtual trainer: A low cost AR simulation of a sudden cardiac arrest emergency. *DIS 2016 – Proceedings of the 2016 ACM Conference on Designing Interactive Systems: Fuse*, 607–618. DOI: https://doi.org/10.1145/2901790.2901914

Don't buy it. I can make that. (2013). *DIY: CPR Manikin*. Don't Buy It. I Can Make That. http://cyylau.blogspot.com/2013/02/diy-cpr-manikin.html

Eric Paredes Foundation. (2023). *Stayin' Alive with CPR*. https://epsavealife.org/what-is-sca/stayin-alive-with-cpr/

Gentner, D., & **Hoyos, C.** (2017). Analogy and abstraction. *Topics in Cognitive Science*, *9*(3), 672–693. DOI: https://doi.org/10.1111/tops.12278

Geri, G., Fahrenbruch, C., Meischke, H., Painter, I., White, L., Rea, T. D., & **Weaver, M. R.** (2017). Effects of bystander CPR following out-of-hospital cardiac arrest on hospital costs and long-term survival. *Resuscitation*, *115*, 129–134. DOI: https://doi.org/10.1016/j.resuscitation.2017.04.016

Goldstein, M., Goldstein, B., Novograd, J., & **Carden, K.** (2018). *Comparison of a Low and high resource model to effectively train college students in compression only cardiopulmonary resuscitation*. https://pillowcpr.com/wp-content/uploads/2019/11/AHAposterRESS2018.pdf. DOI: https://doi.org/10.1161/circ.138.suppl_2.226

Goldstein, M., Goldstein, B., Novograd, J., Wallace, I., Goldstein, L., & **Carden, K.** (2019). *Use of a low resource model for group cardiopulmonary resuscitation training: Knowledge gains and attitude changes*. https://pillowcpr.com/wp-content/uploads/2019/11/AHA-poster-RESS-2019.pdf. DOI: https://doi.org/10.1161/circ.140.suppl_2.392

Gozuen, V. F., Marques, Y. S., & **Pereira, N. V.** (2020). Recycling to save lives: making manikins from recyclable materials for cardiopulmonary resuscitation training. *International Journal for Innovation Education and Research*, *8*(11), 508–520. DOI: https://doi.org/10.31686/ijier.vol8.iss11.2779

Grand Junction Fire Department. (2022). *Build your own DIY CPR mannequin*. https://www.youtube.com/watch?v=7X4QoDUmRtY

Gray, R. (2019). Virtual environments and their role in developing perceptual-cognitive skills in sports. In A.

M. Williams & R. Jackson (Eds.), *Anticipation and Decision Making in Sport*. Routledge. DOI: https://doi.org/10.4324/9781315146270-19

Greif, R., Bhanji, F., Bigham, B. L., Bray, J., Breckwoldt, J., Cheng, A., Duff, J. P., Gilfoyle, E., Hsieh, M.-J., Iwami, T., Lauridsen, K. G., Lockey, A. S., Ma, M. H.-M., Monsieurs, K. G., Okamoto, D., Pellegrino, J. L., Yeung, J., Finn, J. C., Baldi, E., … Zace, D. (2020). Education, implementation, and teams: 2020 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Circulation*, *142*(16_suppl_1). DOI: https://doi.org/10.1161/CIR.0000000000000896

Grupo Salvando Vidas. (2022). *Simulador casero de RCP aplicado al adulto [Video]*. YouTube. https://www.youtube.com/watch?v=8aJxDI_tANc%0A

Haddaway, N. R., Collins, A. M., Coughlin, D., & **Kirk, S.** (2015). The role of Google Scholar in evidence reviews and its applicability to grey literature searching. *PLoS ONE*, *10*(9). DOI: https://doi.org/10.1371/journal.pone.0138237

Hainfeld, H. (1966). Home-made mannequin for first aid classes. *Journal of Health, Physical Education, Recreation*, *37*(2), 65–65. DOI: https://doi.org/10.1080/00221473.1966.10618546

Harris, D. J., Bird, J. M., Smart, P. A., Wilson, M. R., & **Vine, S. J.** (2020). A framework for the testing and validation of simulated environments in experimentation and training. *Frontiers in Psychology*, *11*, 605. DOI: https://doi.org/10.3389/fpsyg.2020.00605

Health & **Safety Solutions LLC.** (2020). *DIY CPR mannequin [Video]*. YouTube. https://www.youtube.com/watch?v=tHaLvQjnRPw

Ihenz, M. (2022). *Paanu gumawa ng DIY CPR mannequin [Video]*. YouTube. https://www.youtube.com/watch?v=MqHg68AEpJ8

Iil Dwi Lactona, S. (2021). Efficacy and knowledge of conducting CPR through online learning during the Covid-19 pandemic: A literature review. *Journal of Public Health Research*, *10*(2), jphr.2021.2208. DOI: https://doi.org/10.4081/jphr.2021.2208

International Federation of Red Cross Red Crescent Societies. (2020). *International First Aid, Resuscitation, and Education Guidelines 2020*. International Federation of Red Cross Red Crescent Societies. www.globalfirstaidcentre.org/resource/international-first-aid-resuscitation-and-education-guidelines-2020-2/

Jones, I., Handley, A. J., Whitfield, R., Newcombe, R., & **Chamberlain, D.** (2007). A preliminary feasibility study of a short DVD-based distance-learning package for basic life support. *Resuscitation*, *75*(2), 350–356. DOI: https://doi.org/10.1016/j.resuscitation.2007.04.030

Laerdal. (n.d.). *Community CPR*. Laerdal Medical. Retrieved May 24, 2023, from https://laerdal.com/nz/products/simulation-training/community-cpr/

Lamboy, D., & **Donohue, P. J.** (2015). Breathing life into CPR training. *Lecture Notes in Computer Science*, *9183*, 777–783. DOI: https://doi.org/10.1007/978-3-319-20816-9_74

Lausa, R. L. (2021). *BPE 223 CPR demonstration | DIY mannequin [Video]*. YouTube. https://www.youtube.com/watch?v=6KeVz53CvPM

Lavoie, J. (2021). CPR mannequin to help teach CPR [Video]. In *YouTube*. Last accessed 25 February 2023, https://www.youtube.com/watch?v=sELTX9pj2kQ [No longer available.]

Life Saving Victoria. (n.d.). *How to make a CPR manikin*. Retrieved May 23, 2023, from https://lsv.com.au/wp-content/uploads/How-to-make-a-CPR-manikin.pdf

Lin, L., Ni, S. Z., Cheng, J., Zhang, Z. X., Zeng, R., Jin, X. Q., & **Zhao, Y.** (2021). Effect of synchronous online vs. face-to-face cardiopulmonary resuscitation training on chest compression quality: A pilot randomized manikin study. *American Journal of Emergency Medicine*, *50*, 80–84. DOI: https://doi.org/10.1016/j.ajem.2021.07.009

Marrodán, I. M. (2022). *Cómo fabricar un muñeco de primeros auxilios para que los niños puedan practicar la RCP [Video]*. YouTube. https://www.youtube.com/watch?v=4-lW6vD3TS4%0A

Masut, J. (2013). *Thorax [Video]*. YouTube. https://www.youtube.com/watch?v=J1lwQw66mW8

Masut, J. (2015). *"Lola" modelo mecánico para aprender RCP [Video]*. YouTube. https://www.youtube.com/watch?v=F0UlkXBGjJ4

McGinnis, M. G. (2000). *Cardiopulmonary resuscitation mannequin*. Patents.Google.Com. https://patents.google.com/patent/US6530783B1/en

Moghimi, M., Stone, R., Rotshtein, P., & **Cooke, N.** (2016). Influencing human affective responses to dynamic virtual environments. *Presence*, *25*(2), 81–107. DOI: https://doi.org/10.1162/PRES_a_00249

Montalban, J. (2021). *CPR by Jaymark Montalban [Video]*. YouTube. https://www.youtube.com/watch?v=DxALviPJoR8

Nakagawa, N., Oliveira, K., Lockey, A., Semeraro, F., Aikawa, P., Macchione, M., Carvalho-Oliveira, R., Gouvêa, G., Boaventura, A., Maiworm, A., Calderaro, M., Hajjar, L., Motta, E., Souza, H., de André, C., Silva, L., Polastri, T., Timerman, S., Carmona, M., & **Böttiger, B.** (2021). Effectiveness of the 40-minute handmade manikin program to teach hands-on cardiopulmonary resuscitation at school communities. *The American Journal of Cardiology*, *139*, 126–130. https://pubmed.ncbi.nlm.nih.gov/33007308/. DOI: https://doi.org/10.1016/j.amjcard.2020.09.032

Nas, J., Thannhauser, J., Van Geuns, R. J. M., Van Royen, N., Bonnes, J. L., & **Brouwer, M. A.** (2021). Optimal combination of chest compression depth and rate in virtual reality resuscitation training: A post hoc analysis of the randomized lowlands saves lives trial. *Journal of the American Heart Association*, *10*(2), 1–6. DOI: https://doi.org/10.1161/JAHA.120.017367

Nas, J., Thannhauser, J., Vart, P., van Geuns, R. J., Muijsers, H. E. C., Mol, J. Q., Aarts, G. W. A., Konijnenberg, L. S. F., Gommans, D. H. F., Ahoud-Schoenmakers, S., & **Al., E.** (2020). Effect of face-to-face vs virtual reality training on cardiopulmonary resuscitation quality: A randomized clinical trial. *JAMA Cardiology*, *5*(3), 328-335. DOI: https://doi.org/10.1001/jamacardio.2019.4992

Noko O. (2021). *DIY CPR mannequin (how to make your own CPR mannequin) [Video]*. YouTube. https://www.youtube.com/watch?v=Iu9Ghos7PwI

Nolan, D. (2020). *DIY dummy 1 [Video]*. YouTube. https://www.youtube.com/watch?v=OOu7WdBwlC0

Nysaether, J. B., Dorph, E., Rafoss, I., & **Steen, P. A.** (2008). Manikins with human-like chest properties—A new tool for chest compression research. *IEEE Transactions on Biomedical Engineering*, *55*(11), 2643–2650. DOI: https://doi.org/10.1109/TBME.2008.2001289

Ohle, R., Moskalyk, M., Boissonneault, E., Bilgasem, A., Tissot, E., & **McIsaac, S.** (2021). Is a homemade cardiopulmonary resuscitation (CPR) trainer non-inferior to a commercially available CPR mannequin in teaching high-quality CPR? A non-inferiority randomized control trial. *Resuscitation Plus*, *6*. DOI: https://doi.org/10.1016/j.resplu.2021.100134

Ohle, R., Moskalyk, M., Boissonneault, E., Simmons, K., & **McIsaac, S.** (2021). A homemade CPR trainer can enable real time practice during online hands only CPR training. In *Resuscitation* (Vol. 158, pp. 71–72). DOI: https://doi.org/10.1016/j.resuscitation.2020.10.045

Ok Ahn, K., McNally, B., Al-Araji, R., Cisneros, C., & **Chan, P. S.** (2023). Sex differences in the association between bystander CPR and survival for out-of-hospital cardiac arrest. *Resuscitation*, *182*, 109603. DOI: https://doi.org/10.1016/j.resuscitation.2022.09.016

Olasveengen, T. M., Mancini, M. E., Perkins, G. D., Avis, S., Brooks, S., Castrén, M., Chung, S. P., Considine, J., Couper, K., Escalante, R., Hatanaka, T., Hung, K. K. C., Kudenchuk, P., Lim, S. H., Nishiyama, C., Ristagno, G., Semeraro, F., Smith, C. M., Smyth, M. A., … Rajendran, K. (2020). Adult basic life support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation*, *142*(16_suppl_1), 41–91. DOI: https://doi.org/10.1161/CIR.0000000000000892

Ouzzani, M., Hammady, H., Fedorowicz, Z., & **Elmagarmid, A.** (2016). Rayyan-a web and mobile app for systematic reviews. *Systematic Reviews*, *5*(1). DOI: https://doi.org/10.1186/s13643-016-0384-4

Parent Heart Watch. (2023). *Hands-only CPR is a bridge to life*. https://parentheartwatch.org/get-involved/learn-cpr-at-home/

Pellegrino, J. L., & **Asselin, N.** (2020). Theoretical organization of motivations to attend first aid education: Scoping review. *International Journal of First Aid Education*, *3*(1), 18–29. DOI: https://doi.org/10.21038/ijfa.2020.0105

Pevida, M. A. (2022). *DIY mannequin making: Proper CPR demonstration [Video]*. YouTube. https://www.youtube.com/watch?v=NNx3RWbw_Ec

Pillow CPR. (n.d.). *Learn pillow CPR*. Retrieved October 18, 2023, from https://pillowcpr.com/

Piscopo, A., Piscopo, I. C., Avezum, A., Pinto, I. M., & **Saraiva, F. K.** (2018). New mannequin made by recyclable plastic bottles for training thoracic compressions at schools. *Circulation*, *138*. https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01935664/full. DOI: https://doi.org/10.1161/circ.138.suppl_2.215

Piscopo, A., Piscopo, I. C., Fonseca, F. A., Pinto, I. M., Saraiva, F. K., & **Avezum, A.** (2018a). A new mannequin made by recyclable PET bottle for training thoracic compressions at schools. *Global Heart. Conference: World Congress of Cardiology & Cardiovascular Health 2018. United Arab Emirates*, *13*(4), 458. DOI: https://doi.org/10.1016/j.gheart.2018.09.292

Piscopo, A., Piscopo, I. C., Fonseca, F. A., Pinto, I. M., Saraiva, F. K., & **Avezum, A.** (2018b). Cardiopulmonary Resuscitation (CPR) mass training for high school children in public schools in Sao Paulo – Brazil – using PET bottle mannequins and recycled material. *Global Heart. Conference: World Congress of Cardiology & Cardiovascular Health 2018. United Arab Emirates*, *13*(4), 458-459. DOI: https://doi.org/10.1016/j.gheart.2018.09.293

Piscopo, A., Piscopo, I. de C. P., de Oliveira, J. C., Saraiva, J. F. K., Fonseca, F. H., Pinto, I. M. F., & **Avezum, Á.** (2018). *Effectiveness of cardiopulmonary resuscitation training using affordable manikin produced with PET bottle*. https://papers.ssrn.com/abstract=4093800

Potts, J., & **Lynch, B.** (2006). The American Heart Association CPR Anytime Program: The potential impact of highly accessible training in cardiopulmonary resuscitation. *Journal of Cardiopulmonary Rehabilitation*, *26*(6), 346–354. DOI: https://doi.org/10.1097/00008483-200611000-00002

Reder, S., Cummings, P., & **Quan, L.** (2006). Comparison of three instructional methods for teaching cardiopulmonary resuscitation and use of an automatic external defibrillator to high school students. *Resuscitation*, *69*(3), 443–453. DOI: https://doi.org/10.1016/j.resuscitation.2005.08.020

Rice, C. L. (1985). *Teaching aid for CPR*. United State Patent 4,619,617.

Roppolo, L. P., Pepe, P. E., Campbell, L., Ohman, K., Kulkarni, H., Miller, R., Idris, A., Bean, L., Bettes, T. N., & **Idris, A. H.** (2007). Prospective, randomized trial of the effectiveness and retention of 30-min layperson training for cardiopulmonary resuscitation and automated external defibrillators: The American Airlines Study. *Resuscitation*, *74*(2), 276–285. DOI: https://doi.org/10.1016/j.resuscitation.2006.12.017

Russell, J. (2020). *CPR training DIY [Video]*. https://www.youtube.com/watch?v=LFzzeVwbFJU

Schroeder, D. C., Semeraro, F., Greif, R., Bray, J., Morley, P., Parr, M., Kondo Nakagawa, N., Iwami, T., Finke, S.-R., Malta Hansen, C., Lockey, A., Del Rios, M., Bhanji, F., Sasson, C., Schexnayder, S. M., Scquizzato, T., Wetsch, W. A., & **Böttiger, B. W.** (2023). KIDS SAVE LIVES: Basic life support education for schoolchildren: A narrative review and scientific statement from the International Liaison Committee on Resuscitation. *Resuscitation*, *188*. DOI: https://doi.org/10.1016/j.resuscitation.2023.109772

Shafiq, U., Ali, B., Masahuling, A., & **Khanji, M. Y.** (2022). The use of a "pillow partner" as a simple, cost-effective, and accessible tool to teach bystander cardiopulmonary resuscitation skills. *Resuscitation*, *181*, 26–27. DOI: https://doi.org/10.1016/j.resuscitation.2022.10.007

Simple kits. (2022). *DIY CPR dummy and home practice [Video]*. https://www.youtube.com/watch?v=GN9-z9qGnmc

Singapore Heart Foundation. (2020). *DIY CPR manikin [Video]*. YouTube. https://www.youtube.com/watch?v=tlI3xo6paLI

Sociedade de Cardiologia do Estado de SP. (2015). *Nós cuidamos do seu coração! Aprenda a fazer o boneco de massagem cardíaca [We take care of your heart! Learn how to do the heart massage dummy] [Video]*. YouTube. https://www.youtube.com/watch?v=EO6GltwBvTc

SOS-KANTO study group. (2007). Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): an observational study. *Lancet*, *369*(9565), 920–926. DOI: https://doi.org/10.1016/S0140-6736(07)60451-6

South Western Ambulance. (n.d.). "How to create your own resuscitation manakin ?? @restartaheart #restartaheart #savinglifestogether #resuscounciluk." Instagram. https://www.instagram.com/p/CGZwyyFFBY4/

Spokane Parks & **Recreation.** (2020). DIY CPR manikin [Video]. In *Vimeo*. https://vimeo.com/403838144

Supa, J. L. (2021). *DIY mannequin and CPR demonstration [Video]*. https://www.youtube.com/watch?v=IEb2GANFzKo

Szpilman, D. (2019). *Como fazer um manequim de RCP de forma simples [Video]*. YouTube. https://www.youtube.com/watch?v=DNnyGnovkPo

Tanaka, S., White, A. E., Sagisaka, R., Chong, G., Ng, E., Seow, J., Mj, N. A., Tanaka, H., & **Ong, M. E. H.** (2017). Comparison of quality of chest compressions during training of laypersons using Push Heart and Little Anne manikins using blinded CPRcards. *International Journal of Emergency Medicine*, *10*(1). DOI: https://doi.org/10.1186/s12245-017-0147-6

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine*, *169*(7), 467–473. DOI: https://doi.org/10.7326/M18-0850

Unknown. (n.d.). *Öva HLR med provisoriskt material – gör en enkel övningsdocka [Practice CPR with makeshift materials – make a simple practice dummy]*. Retrieved February 27, 2023, from https://sway.office.com/7FkPHoXaDHIacLNi?ref=Link&loc=mysways

Van Raemdonck, V., Aerenhouts, D., Monsieurs, K., & **De Martelaer, K.** (2017). A pilot study of flipped cardiopulmonary resuscitation training: Which items can be self-trained? *Health Education Journal*, *76*(8), 946–955. DOI: https://doi.org/10.1177/0017896917727561

Van Raemdonck, V., Monsieurs, K. G., Aerenhouts, D., & **De Martelaer, K.** (2014). Teaching basic life support: a prospective randomized study on low-cost training strategies in secondary schools. *European Journal of Emergency Medicine*, *21*(4), 284-290. DOI: https://doi.org/10.1097/MEJ.0000000000000071

Van Raemdonck, V., Monsieurs, K. G., & **De Martelaer, K.** (2010). Comparison of four CPR training strategies in secondary schools including low-cost alternative training materials: A randomised study. *Resuscitation*, *81*(2), S29–S30. DOI: https://doi.org/10.1016/j.resuscitation.2010.09.128

Wanner, G., Berray, S., & **Osborne, A.** (2016, December 16). *DIY CPR: Learn CPR with a roll of toilet paper! [Video]*. YouTube. https://www.youtube.com/watch?v=0-7EUhtXLRY. DOI: https://doi.org/10.1186/s12873-016-0110-5

Wanner, G. K., Osborne, A., & **Greene, C. H.** (2016). Brief compression-only cardiopulmonary resuscitation training video and simulation with homemade mannequin improves CPR skills. *BMC Emergency Medicine*, *16*(1). DOI: https://doi.org/10.1186/s12873-016-0110-5

Whitehead, J. (2021). *DIY CPR dummy tutorial [Video]*. https://www.youtube.com/watch?v=vcCi_d0PgcI

Wijaya, S., Dwi Ari Wibowo, W., Susmini, S., & **Soewito, B.** (2023). Development of cardiopulmonary resuscitation pillows for increasing number of bystanders CPR In Lubuklinggau City. *International Journal of Nursing and Health Services*, *6*(2), 145–153. DOI: https://doi.org/10.35654/ijnhs.v6i2.703

YMCA Aquatics. (2023, May 26). *DIY female CPR manikins*. Alive Solutions Blog. https://alive-solutions.com/blog/f/diy-female-cpr-manikins

Youth Heart Watch Philadelphia. (2020). *Tips for making your own DIY CPR manikin*. https://www.projectadam.com/ProjectADAM/COVID-191/DIYCPRManikin1.pdf

Ypil, J. M. (2021). *How to perform CPR [Video]*. YouTube. https://www.youtube.com/watch?v=Fcw8wxB9Qu4