QUESTION

"Blended learning approach for life support education"	
POPULATION:	Participants undertaking an accredited life support course (e.g. BLS, ACLS/ALS, PALS, ATLS)
INTERVENTION:	Blended learning approach
COMPARISON:	Non blended learning approach (stratified to subgroups of online only and face-to-face only)
MAIN OUTCOMES:	Knowledge acquisition/retention (end of course, 6 months, 1 year), skills acquisition/retention (end of course, 6 months, 1 year), participant satisfaction (end of course), patient survival, implementation outcomes (cost, time needed)
BACKGROUND:	Blended learning is an educational approach that has gained popularity in medical education and professional development. It combines the advantages of both face-to-face and online approaches and gives learners more control over the educational content to be engaged, sequencing, and pace of learning as well as flexibility around when and where learning takes place. (1) Online elements are usually, but not always, delivered prior to the face-to-face element. The ever-increasing demands upon clinical service delivery time have historically been a driver to reduce teaching and study leave time. As a result, there is a need within healthcare education for flexible, tailored, and timely methods of teaching (2) which are also efficient and cost-effective.(3) A blended learning approach has the ability to deliver cost savings for both learners and teaching institutions when compared with conventional classroom learning whilst still maintaining face-to-face contact. (4-6) As an additional rationale, online learning may hold advantages from a learning theory perspective. Learning in such formats may be better tailored to the learner, be it in respect to different levels of pre-knowledge or for different learning styles, pace of learning etc. (7) More recently, the impact of the COVID-19 pandemic on the feasibility of face-to-face interactions and teaching has been profound, making the use of technology to facilitate learning a necessity rather than an option. (8-11) Although a blended learning approach appears to be an obvious solution to some of these challenges and drivers, it is important that this teaching approach is formally evaluated. This is particularly important with regard to specific targeted educational interventions, such as accredited life support courses. The 2020 CoSTR strongly recommended "providing the option of eLearning as part of a blended-learning approach to reduce face-to-face training time in ALS courses (very low- to low-certainty evidence)" (12) This systematic review is designed to look at the impact of all forms of blended learning on all accredited life support courses.
CONFLICT OF INTERESTS:	Andy Lockey is a Trustee of Resuscitation Council UK – who provide blended and non-blended life support training.

ASSESSMENT

Problem

Is the problem a priority?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	The COVID-19 pandemic has significantly impacted upon the ability to deliver pure face-to-face training. The skills needed to be taught mean that pure online learning may not be sufficient. There is evidence of the development of blended learning variants of life support courses to enable training to continue in times of pandemic and potentially in the post-pandemic era as well.	Attendance of participants on accredited life support courses come at a cost - both financial and time - to stakeholders including participants themselves and their institutions. Blended learning offers an opportunity to deliver such training with a requirement for participants and faculty to take a shorter time away from clinical duties. It is important to assess whether this alternative approach to training is effective.

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Basic Life Support** The review included 14 studies (13-26). For the outcome of BLS knowledge (post intervention), one study found a statistically significant benefit for blended learning (21), one study found a statistically significant benefit for face-to-face only (17), one study found increased requirements for knowledge remediation in the blended learning group (22), and two studies found no significant difference between the blended learning and control groups (14, 16). There was no significant difference between the groups at any time point between 2 and 12 months (14, 16, 17, 21). All studies were of adult BLS courses. For the outcome of BLS skills (post intervention), three studies found a statistically significant benefit for blended learning (14, 18, 26). One of these studies also found a statistically significant benefit for face-to-face only for total number of chest compressions (18). One study of infant BLS found better performance with blended learning in a range of BLS components, but no analysis was performed for statistical significance (23). The remaining eight studies (including one of infant BLS) found no significant difference between the intervention and control groups (13, 16, 17, 19-22, 24). For BLS skills retention, one study found no significant difference between the groups at 2 months (21). One study found a statistically significant benefit for blended learning at 3 months when compared to online learning only for compression depth, but the opposite for compression rate (26). Two studies found a statistically significant benefit for blended learning at 6 months (14, 26). The remaining four studies found no significant difference between the intervention and control groups (16, 18, 20, 24). There was no significant difference between groups for one study at 9 months (17) and one study at 12 months (16). For the outcome of attitudes, there was evidence of positive attitudes to all forms of training (20, 22, 24, 26). For the outcome of costs, the single cost analysis study found a notable financial benefit for teaching BLS via a blended learning approach (15). **Adult advanced cardiac life support:** The review included eight studies (27-34). For the outcome of ALS knowledge (post intervention), two studies found significantly higher scores in the blended learning group (27, 34), whilst the remainder of the studies found no significant difference between the groups (28, 32, 33). There was no significant difference between groups for one study at 7 months (28).	Lack of consistency of settings, duration of training, varying study designs and different types of outcome measures contribute to substantial clinical and methodological heterogeneity for both BLS and ALS sub-groups. As such, it is not feasible to perform any meta-analysis for any of the outcomes. For ATLS, only one study was available. Pre-post studies lack concurrent control group, therefore confounding factors are present. Despite the heterogeneity of evidence, the majority of the analyses show no detrimental effect for blended learning and a treatment effect in favour of blended learning in some domains.

	For the outcome of ALS skills (post intervention), one pilot study (33) found significantly higher scores in the control group however a subsequent study of the revised version of the same course found significantly higher scores in the blended learning group (34). The remainder of the studies found no significant difference between the groups (27, 28, 30, 32). There was a diversity of attitudes with three studies finding a preference for blended learning (27, 30, 32) and two studies finding a preference for face-to-face learning (28, 31). For the outcome of costs, two studies found a notable financial benefit for teaching ALS via a blended learning approach (29, 33). **Adult trauma life support:** One study found that a blended learning approach for Advanced Trauma Life Support is better in terms of knowledge outcomes (35). Overall pass rates were better but there was no specific description of the breakdown of skills performance as opposed to knowledge outcomes in determining the final result so a conclusion about skills training cannot be made.	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large ○ Moderate ● Small ○ Trivial ○ Varies ○ Don't know	Two small studies with a total of 259 participants found no significant difference that favoured the control group for post intervention knowledge scores or requirements for knowledge remediation in Basic Life Support (17, 22). Otherwise, there was no evidence to suggest any other detrimental outcomes from this intervention for BLS. One study of a pilot approach to e-ALS training showed significantly higher skills in the traditional group for immediate knowledge retention (33), but this was not evidenced in the follow up study of the revised course (34).	Despite the heterogeneity of evidence, the majority of the analyses show no detrimental effect for blended learning and a treatment effect in favour of blended learning in some domains.

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	**BLS and adult advanced cardiac life support** • The quality of evidence was very low for knowledge, skills, and attitudes. • Downgraded for risk of bias, indirectness, and inconsistency. **Advanced Trauma Life Support** • The quality of evidence was very low for knowledge, skills, and attitudes. • Non-RCT study downgraded for risk of bias, and imprecision.	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	Participant and faculty attitudes were assessed, and were on the whole favourable to the intervention of blended learning. No studies examined the critical outcome of patient outcomes or good neurological function. No studies explored the values of key stakeholders or family members.	In respect to the outcomes 'improved patient outcome' and 'good neurologic outcome' it might not be scientifically sound to link the 'type of course format' to outcomes at the patient level given the indirectness of effects with a substantial number of potential confounders.

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ● Favors the intervention ○ Varies ○ Don't know	Yes	

Resources required

How large are the resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○Moderate costs ○ Negligible costs and savings ○ Moderate savings ● Large savings ○ Varies ○ Don't know	**BLS** One study (15) demonstrated that initial set up costs of a blended learning programme resulted in a large unspecified net loss. There was however a net profit of €10,530 at 5 years in the blended learning group compared to a loss of €1,754 in the control group. **Adult advanced life support** Results from two studies (29, 33) showed that the blended learning course is superior to the traditional course in terms of cost reductions. A study from Singapore found 61% savings over 5 years if blended-ACLS were to be used instead of traditional-ACLS (29). The estimated annual cost to conduct blended-ACLS and traditional-ACLS were S$43,467 and S$72,793, respectively. Furthermore, one of the UK studies reported more than 50% cost reductions in which the total costs per participant were $438 for blended ALS training and $935 for traditional ALS training (33).	Significant costs may be needed by accrediting institutions to develop and update online materials and host learning management systems to deliver online content. This may vary depending upon the complexity of content needed. Over time these costs may be mitigated for these institutions by the ongoing savings. Other stakeholders (i.e. participants, those funding placements on these courses) are likely to see only a positive cost saving from blended learning courses.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Very low ○ Low ○ Moderate ● High ○No included studies	High certainty of evidence for BLS and adult advanced cardiac life support. No evidence available for Advanced Trauma Life Support.	Costs may be variable depending upon pre-existing resources within different programs.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ● Favors the intervention ○ Varies ○ No included studies	Evidence shows that following investment in the development of resources, the intervention is cost effective for BLS and adult advanced cardiac life support. No evidence available for Advanced Trauma Life Support.	The potential for lives saved by health care professional's participation in these courses outweighs the costs of providing these courses.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ● Varies ○ Don't know	No evidence presented.	Blended learning approaches may improve accessibility to those in remote locations and in times of pandemic for participants otherwise unable to attend traditional courses. Conversely, a blended learning approach may disadvantage those without access to online learning. Individual approaches to learning may vary and a blended learning approach may not suit all participants.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	Attitudinal results were favourable for blended learning approaches to BLS and adult advanced cardiac life support. No evidence available for Advanced Trauma Life Support.	There has been considerable pressure from key stakeholders for many years to reduce costs associated with life support courses. In addition, reducing the time needed away from the clinical workforce is a priority for participants and faculty alike. Any strategy that reduces costs and time out is likely to be acceptable to stakeholders.

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Yes	Requires access to online learning. Therefore may not be feasible in all settings (e.g. low resource settings may not be able to provide online access or various media, and may therefore prefer traditional face-to-face teaching). The costs of programme developers, online support, ongoing data management, and web development may also impact upon the feasibility for developing a blended learning approach in lower resource settings.

SUMMARY OF JUDGEMENTS

	JUDGEMENT						
PROBLEM	No	Probably no	**Probably yes**	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	**Small**	**Moderate**	**Large**		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	**Small**	**Trivial**		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	**Favors the intervention**	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	**Large savings**	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	**High**			**No included studies**
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	**Favors the intervention**	Varies	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	**Varies**	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	Probably yes	**Yes**		Varies	Don't know

TYPE OF RECOMMENDATION

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	**Strong recommendation for the intervention**
○	○	○	○	●

CONCLUSIONS

Recommendation

We recommend a blended learning as opposed to non-blended approach for life support training where resources and accessibility permit its implementation (strong recommendation, very low quality of evidence).

Justification

- A blended learning approach is grounded in a strong framework from educational theory
- Blended learning approaches result in similar or better educational outcomes for participants
- A blended learning approach can enable ongoing training of life support skills for those in remote locations, lower resource settings, and in times of pandemic
- A blended learning approach may not be feasible in areas where access to online learning is limited or unavailable
- Non-blended learning approaches (i.e. face-to-face only or online only) are an acceptable alternative where resources or accessibility do not permit the implementation of a blended learning approach.
- The majority of the research evidence used 'face-to-face' only as the control group, with very limited evidence for 'online only' as the control group
- Blended learning enables consistent messaging with regard to content which can be particularly beneficial for pre-course preparation.
- Participant and stakeholder costs are reduced with a blended learning approach
- Duration of face-to-face training is reduced, although time is still needed to complete the online component

Subgroup considerations

Implementation considerations

- Set up costs for the development of online teaching materials and learning management systems may be significant for accrediting institutions

Monitoring and evaluation

Research priorities

- Future studies need to establish the elements of instructional delivery that are associated with better educational outcomes
- Are certain levels of blended learning (i.e. how much, what exactly, when used) more beneficial than other when compared with each other
- Does a blended learning approach to life support education result in better patient outcomes
- Do certain sub-groups of participant (e.g. first time vs recertificating) have better educational outcomes from a blended learning approach?
- Further studies are needed for blended learning compared with online only learning.

Recommended CoSTR:

We recommend a blended learning as opposed to non-blended approach for life support training where resources and accessibility permit its implementation (strong recommendation, very low quality of evidence).

Values and preferences statement:

In making this recommendation we recognize that:

- A blended learning approach is grounded in a strong framework from educational theory
- Blended learning approaches result in similar or better educational outcomes for participants
- A blended learning approach can enable ongoing training of life support skills for those in remote locations, lower resource settings, and in times of pandemic
- A blended learning approach may not be feasible in areas where access to online learning is limited or unavailable
- Non-blended learning approaches (i.e. face-to-face only or online only) are an acceptable alternative where resources or accessibility do not permit the implementation of a blended learning approach.
- The majority of the research evidence used 'face-to-face' only as the control group, with very limited evidence for 'online only' as the control group
- Blended learning enables consistent messaging with regard to content which can be particularly beneficial for pre-course preparation.
- Participant and stakeholder costs are reduced with a blended learning approach
- Duration of face-to-face training is reduced, although time is still needed to complete the online component

Knowledge gaps:

- The elements of instructional delivery that are associated with better educational outcomes;
- Are certain levels of blended learning (i.e. how much, what exactly, when used) more beneficial than other when compared with each other;
- Does blended learning life support educational lead to better patient outcomes
- Do certain sub-groups of participant (e.g. first time vs recertificating) have better educational outcomes from a blended learning approach?
- Further studies are needed for blended learning compared with online only learning

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