Concordance between the 2010 and 2015 Resuscitation Guidelines of International Liaison Committee of Resuscitation Councils (ILCOR) members and the ILCOR Consensus of Science and Treatment Recommendations (CoSTRs)

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ABSTRACT

Background

Cardiac arrests are associated with poor outcomes. The International Liaison Committee on Resuscitation (ILCOR) evaluates resuscitation science and produced, until 2015, five-yearly consensus statements on treatment recommendations (CoSTRs), informing global resuscitation guidelines (RGs).

We aimed to identify similarities/differences in RGs from ILCOR members, noting concurrence over time, and CoSTRs influence on these guidelines.

Methods

We considered the component elements of paediatric and adult, basic and advanced RGs, published in 2010 and 2015, along with matching ILCOR CoSTRs to examine their influence. We contacted the responsible councils when guidelines were unavailable online.

Results

Complete RGs were found for six of the seven ILCOR council members. The Resuscitation Council of Asia only had adult basic life support (BLS) guidelines in English. Three members used the AHA guidelines. Therefore, five rather than seven sets of RGs were compared to the CoSTRs.

Concurrence between CoSTRs recommendations and ILCOR council member's RGs has improved over time. Minor variations were identified in both basic and advanced life support, with most variance in paediatric guidelines, but these narrowed over time.

Conclusion

The improved concurrence across the RGs with the CoSTRs suggests that ILCOR members accept and hence incorporate CoSTRs recommendations to inform their own RGs. This is one step towards the development of international universal guidelines for adult and paediatric resuscitation.

Concordance between the 2010 and 2015 Resuscitation Guidelines of International Liaison Committee of Resuscitation Councils (ILCOR) members and the ILCOR Consensus of Science and Treatment Recommendations (CoSTRs)

INTRODUCTION

The International Liaison Committee of Resuscitation Councils (ILCOR) was set up in 1992 to consolidate scientific evidence with expert opinion and has produced international recommendations on resuscitation every 5 years up until 2015.[1] ILCOR comprises of: the American Heart Association (AHA), European Resuscitation Council (ERC), Heart and Stroke Foundation of Canada (HSFC), Australian and New Zealand Committee on Resuscitation (ANZCOR), Resuscitation Council of Southern Africa (RCSA), Inter-American Heart Foundation (IAHF) and Resuscitation Council of Asia (RCA).[1]

Each ILCOR task force identified and prioritised topics to support resuscitation guideline development. Following consultation with member organisations and the public, ILCOR published the "Consensus on Science and Treatment Recommendations (CoSTRs)". Each CoSTR included a resume of reviewed scientific literature to inform the recommendations, with 'Values and Preferences statements' reflecting the task force's deliberations in reaching its recommendations, and a separate section on the topic's knowledge gaps. ILCOR council members drew up and published their own resuscitation guidelines (RGs) after each set of CoSTRs was produced. Where clear recommendations, supported by scientific evidence, were made, it would be reasonable to assume these guidelines were consistent with the accompanying CoSTR.

There is significant inter-country variation in survival to discharge post-cardiac arrest. Reasons for variations and potential influences on cardiac arrest outcomes include differences in RGs, patient factors, delivery of bystander cardiopulmonary resuscitation (CPR) (including the use of telephonic assistance to lay members of public in its delivery), public access to defibrillation, emergency medical services and other system factors.[2 3] Although there are an increasing number of resuscitation

registries, data on cardiac arrest occurrence, treatment and outcomes are scarce, consequently the impact of these different factors is unknown.[4]

The aim of this review is to compare ILCOR members' guidelines, and assess whether CoSTR recommendations were followed in the related guidelines. By identifying the similarities and differences between CoSTRs and published RGs at two time points five years apart, we have assessed their alignment over time. The closer the alignment, the less likely that RGs are a potential cause of inter-country variation in CPR outcomes.

METHODS

Setting up ILCOR necessitated the development of international understanding, cooperation and agreement on the collection, analysis and interpretation of research evidence.[1] As any initial variations in RGs could be attributed to the setting up of the collaboration, we focused on the RGs published following the 2010 and 2015 CoSTRs.

Between October 2014 and June 2015, the team searched resuscitation council websites for paediatric and adult, basic and advanced life support RGs, and any accompanying algorithms based on the 2010 CoSTRs. We repeated this in December 2015 to March 2016 for guidelines based on 2015 CoSTRs.

We included basic and advanced life support guidelines for adults and children issued in 2010 and 2015 and published in English.

Each ILCOR council member's guideline was examined and key information from the resuscitation algorithms extracted and tabulated by one author and independently checked by a second. Guidance on the provision of chest compressions to ventilation ratio, chest compression depth, rate of chest compressions and ventilation rate were included as these are key parts of high performance CPR fundamental for optimal resuscitation.[5] Other CPR components examined included: delivery of rescue breaths before chest compressions; defibrillation energy for shockable rhythms; administration timing of epinephrine in shockable/non-shockable rhythms; epinephrine and amiodarone dosages; and their use in shockable rhythms.

The same information was extracted from the relevant CoSTR recommendation articles for 2010 and 2015. Where an item was not included in the 2015 or 2010 recommendations, we searched publications from 2005, 2000 and 1997 to identify the most recent review of that item. Quality assessment decisions on the evidence supporting recommendations were recorded.

One author assessed and a second checked concordance between guidelines and CoSTR recommendations; differences of opinion were resolved through discussion or referral to a third author. We considered concordance to have been met where a resuscitation guideline wholly or in part matched the CoSTR recommendation.

RESULTS

CoSTR statements for 2010 and 2015 were obtained from the ILCOR website (www.ILCOR.org).[5-10] CoSTR statements on paediatric basic life support for 2000, and paediatric advanced life support for 1997 were also obtained to identify recommendations not covered in subsequent statements.[11 12]

We identified resuscitation guidelines in English for adult and paediatric, basic and advanced life support for six of the seven ILCOR councils for 2010[13-26] and 2015.[27-39] The only guideline available in English from the RCA at this time was the 2015 adult lay rescuer one person CPR and for the automated external defibrillator algorithm.[36] The RGs were either freely available on the AHA, ANZCOR, ERC, RCA and RCSA websites or were obtained directly from the relevant council.

The RCA are currently in the process of writing other algorithms to add to the adult BLS. The Japanese Resuscitation Council 2015 guidance was available on their website, with an English version in preparation. The Singapore Resuscitation First Aid Council and Korean Resuscitation Council have 2010 and 2015 guidelines on their websites. However, data from these individual countries were not extracted as their guidelines were not ILCOR Council member representative.

RCSA is a long-standing contributor to forming guidelines for CPR and to the Emergency Cardiovascular Care committee, with training centres in: Botswana; Kenya; Nigeria; South Africa; Tanzania; Zambia and Zimbabwe, all teaching AHA guidance. RCSA have adapted local guidelines from current ILCOR

recommendations.[17 20 25-27 39] Other African resuscitation councils such as Kenya are not ILCOR members.

HFSC and IAHF use the AHA guidelines, therefore five rather than seven sets of guidelines have been reviewed. The information extracted from ILCOR council members' resuscitation guidelines for 2010 and 2015 together with the CoSTR recommendation for the relevant year are presented for paediatric and adult basic life support (BLS), and advanced life support (ALS) in supplementary tables 1 to 4.

Concurrence between recommendations in CoSTR and items in ILCOR council members' paediatric CPR guidelines was good but not completely aligned (Table 1). In 2010, three sets of BLS guidelines put compressions before rescue breaths, when CoSTR recommended rescue breaths before compressions. The 2010 CoSTR recommendation was not based on any research evidence. In 2015, when low quality evidence supported the CoSTR recommendation, only one council member's guideline was out of concordance on this item. There were two items of non-concurrence for paediatric ALS CPR guidelines in 2010: ventilation rate (breaths/minute) and shockable epinephrine timing in 2010. Both items were revised in 2015 to give complete concordance. The CoSTR recommendation of 2010 for these two items was based on general consensus, local availability and custom in 1997. In the 2015 review, CoSTR identified very low quality evidence to support their recommendation. Concurrence on rescue breaths before compressions in the Paediatric ALS recommendations remained at 75% between 2010 and 2015. Level of evidence went from indeterminate (from 1997 recommendations) to Very low quality in the 2015 review.

INSERT TABLE 1 HERE

For adult CPR guidelines, concurrence between recommendations in CoSTR and items in ILCOR council members' is shown in Table 2. There was complete concurrence on all items for adult BLS guidelines in both 2010 and 2015. For adult ALS, in both 2010 and 2015, CoSTR recommended shockable epinephrine be given after a third shock. Level of evidence in 2010 was judged to be 4-5 and in 2015 only low quality evidence was found. In 2010, one set of guidelines, and in 2015, two sets

of guidelines recommended it be given after a second shock. This was the only item overall where concurrence fell over time.

INSERT TABLE 2 HERE

ILCOR council members' paediatric guideline concurrence with CoSTR recommendations has improved over time for both BLS and ALS advice (Table 3). Only the AHA had an item of non-concurrence for paediatric BLS and ALS in 2010 and 2015.

INSERT TABLE 3 HERE

There was 100% concordance over time for all council member's adult BLS guidelines compared to matched CoSTR recommendations (Table 4). In 2015, for adult ALS guidelines, AHA and ECR both deviated from the CoSTR on the timing of shockable epinepherine, but otherwise agreed on all other items.

INSERT TABLE 4 HERE

DISCUSSION

ILCOR leads on producing scientifically robust evidence that informs RGs around the world, working with the transcontinental, regional and national resuscitation councils. The process allows experts to review and discuss the evidence in a systematic and transparent manner, identifying gaps in the scientific resuscitation literature and providing recommendations to enhance care of the most critically ill patients.

For our study, we anticipated reviewing the RGs of the seven member-councils of ILCOR but identified a collaborative approach by three of the seven members in that the HSFC and IAHF share in the production and use the AHA RGs. This reduced the potential for variations to five sets of RGs. Of these, we assessed four complete sets of RGs and the adult BLS guidelines from the Resuscitation Council of Asia.

Some variations were identified between ILCOR member RGs for both basic and advanced life support; most differences seen in paediatric CPR algorithms reduced over time. In paediatric BLS, rescue breaths before compressions had the weakest

concurrence between RGs and CoSTR. The concept that the majority of paediatric cardiac arrests are secondary to respiratory failure means there is a focus on early ventilation in paediatric BLS guidance not seen in adult BLS guidelines. There is no formal scientific evidence for this position. In 2010, ILCOR members may have modified their guidance based on their experience with the population they serve. In 2015, improved concordance across the councils with the CoSTRs suggests that ILCOR recommendations even though based on very low quality evidence had been more readily accepted and incorporated into council guidance.

Non-concurrence in 2010 paediatric ALS guidance was seen in ventilation rate (breaths/minute) and the timing of epinephrine in shockable resuscitation. Gaps in CoSTRs, owing to a lack of high quality evidence, were filled by individual ILCOR members in their RGs to give assistance to clinicians and lay people undertaking resuscitation. Both items were reviewed by the ILCOR scientific process, which resulted in a complete concordance by all councils with the CoSTR in 2015. Although these 2015 recommendations were based on very low quality evidence, this may have been considered sufficient compared with the previous consensus, availability and custom basis for recommendations. Potentially a reflection of the value put on research evidence.

ILCOR accepts that variation may exist between CoSTRs and subsequent resuscitation guidance. It is recognised that differences in geography, economics, processes and practice, along with availability of equipment and drugs, will influence interpretation and implementation.[40] In addition, despite the desire to base recommendations on high quality scientific evidence, only 1% of CoSTR recommendations were based on “level A” standard, that is, high-quality evidence from more than one randomized control trial (RCT).[41] Owing to the nature of cardiac arrests, there are few RCTs in humans. Most guidelines are based on retrospective studies, animal studies and expert consensus statements.[42] RCTs are even more rare in paediatric cardiac arrests, making it difficult to underpin recommendations with evidence.[43] Only for paediatric recommendations did ILCOR state ‘in the absence of specific paediatric data (outcome validity), recommendations may be made or supported on the basis of common sense (face validity) or ease of teaching or skill retention (construct validity)’. The low survival rate from asystolic paediatric cardiac arrest is a further obstacle to undertaking robust studies.[40]

ILCOR member guideline developers provide practical guidance on resuscitation for laypeople and healthcare professionals. In addition to CoSTR recommendations, development of their guidance is likely to be based on previous existing practices, and expert local consensus opinion within individual ILCOR councils. For example, CoSTR recommendation in the timing of delivery of epinephrine in adult shockable rhythms advised delivery after the third shock. In 2010, one set of guidelines, and in 2015, two sets of guidelines recommended delivery after the second shock. Minor variations and reluctance to make small changes in resuscitation guidelines may be in an effort to keep by-stander CPR as simple and memorable as possible given the re-training and spread of information that would be required. Ensuring all health professionals are kept up to date is a major challenge, although ILCOR Council members provide a range of BLS, ALS and Automated External Defibrillator (AED) training and there are efforts at standardisation, such as the adult ALS courses for healthcare professionals which are cross-recognised by ARC, NZRC and ERC.[44 45] Providing BLS training to the public, who could potentially make a significant contribution to improving outcomes for out of hospital arrests, is also a huge task and it is already known there is limited recognition and understanding of the signs for AEDs.[46] This is not helped by the use of signs other than the ILCOR universal AED sign.[46]

We recognise that this review has a number of limitations. ILCOR was set up in 1992 to establish an international collaboration and has, until 2015, produced international recommendations on resuscitation every 5 years. Owing to the difficulties in obtaining superseded versions of guidelines and our belief that developing an international collaboration takes considerable effort and time, causing a delay in the alignment of ILCOR council recommendations, we only reviewed the 2010 and 2015 guidelines.

The assumption that the CoSTR process and output is the gold standard for CPR could be seen as a limitation. Given the nature of the international collaboration and the rigorous methods involved in the production of CoSTR recommendations, we feel this is not unreasonable. CoSTR publications are based on the best available evidence, and limitations are stipulated where the evidence base is less robust than is desirable, or lacking altogether.

Finally, the process for identifying recommendations and guideline items and the decisions about concurrence involve a degree of subjectivity. We acknowledge this as a potential weakness, but attempted to minimise bias and human error through duplicate independent review by authors.

In CoSTRs, a lack of RCTs means a reliance on observational studies, which may incorporate significant confounders, meaning there may be inherent biases that are difficult to account for. Consensus opinion is used in the statements owing to the absence of scientifically rigorous evidence. The changes in concordance in each case identified, mirrors the change in quality of supporting evidence. Low quality evidence replacing consensus, availably and custom showed increased concordance. The one case where the level of evidence changed from a rating of 4-5 to low quality evidence and there was no change in the recommendation was the only time concordance decreased. In the absence of high quality evidence, future recommendations need to be informed by international data on the outcomes for cardiac arrests. However, difficulties in identifying where information may be available and forming effective collaborations to collate the data are barriers to this happening. The widespread collection of a standardised dataset on the causes of cardiac arrest, resuscitation efforts and short-, medium- and long-term outcomes could provide vital missing epidemiological data that could greatly enhance scientific knowledge and improve outcomes for patients worldwide, aiding in strategies to achieve better morbidity and mortality in adults and children alike. ILCOR is currently working on providing such templates, having published such standardized outcomes measures for adult practice.[47]

Although ILCOR council members publish their RGs, a number of countries included in council member geographic areas also produce their own guidance. For example, a number of countries within Asia have their own RGs. This may be because the RCA has yet to overcome issues of multiple languages and cultural differences within member countries to produce a full set of guidelines acceptable to everyone. Future work could involve comparing all international/ regional/ national RGs used in practice (ideally unrestricted by language). The collection of relevant data within cardiac arrest registries in the areas of ILCOR members which include adult and paediatric information would provide valuable guidance in determining the most

effective RGs. The impact of differences between guidelines and changes in guidelines could be studied overtime, providing direct evidence of effect. This may also identify how the change to continuous review of CoSTRs is being taken up and implemented within RGs.

CONCLUSION

Concurrence with CoSTRs and RGs of ILCOR council members has improved over time. Minor variations identified in this review between RGs of ILCOR council members have highlighted differences in approach which, if documented across the related populations, could provide useful insights into their impact on patient survival and other outcomes.

The significant inter-country variation in survival to discharge post cardiac arrest is multifactorial. The good concurrence of recommendations to the CoSTR suggests that the individual RGs are not the cause for the inter-country variation in CPR outcomes. The creation of ILCOR has produced a unique opportunity for global collaboration, as experts can effectively communicate and work together to develop guidelines based on evidence rather than habit, tradition, or peer pressure. At ILCOR's inception, the idea was for RGs to be internationally accepted, leading to universal guidelines. Our review demonstrates this goal is well on the way to being achieved.

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I.M. is a member of ILCOR.

S.H., A.B., J.H., K.L., N.S. declare they have no conflicts of interest to disclose.

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Table 1: Concurrence between recommendations in CoSTR and items in ILCOR council members' paediatric CPR guidelines

RECOMMENDATION	PAEDIATRIC BASIC LIFE SUPPORT		
	2010	**2015**	**Direction of alignment**
Rescue breaths before compressions	1/4 (25%)[$$]	3/4 (75%)	↑
Chest compressions to ventilations ratio	4/4 (100%)	4/4 (100%)	**↔**
Chest compression depth	4/4 (100%)	4/4 (100%)	**↔**
Rate of chest compressions (compressions/ minute)	4/4 (100%)[$$]	4/4 (100%)	**↔**
	PAEDIATRIC ADVANCED LIFE SUPPORT		
Rescue breaths before compressions	3/4 (75%)[$]	3/4 (75%)	↔
Chest compression to ventilation ratio	4/4 (100%)	4/4 (100%)	**↔**
Chest compression depth	4/4 (100%)	4/4 (100%)	**↔**
Rate of chest compressions (compressions/minute)	4/4 (100%)[$]	4/4 (100%)	**↔**
Ventilation rate (breaths/minute)	2/3 (66%)[$]	4/4 (100%)	**↑**
Shockable Energy	4/4 (100%)	4/4 (100%)	**↔**
Shockable Epinephrine timing	1/3 (33%)[$]	4/4 (100%)	**↑**
Shockable Amiodarone	3/3 (100%)	4/4 (100%)	**↔**
Non-Shockable Epinephrine timing	3/3 (100%)[$]	4/4 (100%)	**↔**
Epinephrine dose	3/3 (100%)	4/4 (100%)	**↔**

Bold arrows indicate 100% concordance. Comparison is with 1997[$] or 2000[$$] recommendations.

Table 2: Concurrence between recommendations in CoSTR and items in ILCOR council members' adult CPR guidelines

RECOMMENDATION	ADULT BASIC LIFE SUPPORT		
	2010	2015	Direction of alignment
Rescue breaths before compressions	4/4 (100%)	5/5 (100%)	↔
Chest compressions to ventilations ratio	4/4 (100%)	5/5 (100%)	↔
Chest compression depth	4/4 (100%)	5/5 (100%)	↔
Rate of chest compressions (compressions/ minute)	4/4 (100%)	5/5 (100%)	↔
	ADULT ADVANCED LIFE SUPPORT		
Rescue breaths before compressions	4/4 (100%)	4/4 (100%)	↔
Chest compression to ventilation ratio	4/4 (100%)	4/4 (100%)	↔
Chest compression depth	4/4 (100%)	4/4 (100%)	↔
Rate of chest compressions (compressions/minute)	4/4 (100%)	4/4 (100%)	↔
Ventilation rate (breaths/minute)	4/4 (100%)	4/4 (100%)	↔
Shockable Energy	3/3 (100%)	4/4 (100%)	↔
Shockable Epinephrine timing	2/3 (66%)	2/4 (50%)	↓
Shockable Amiodarone	3/3 (100%)	4/4 (100%)	↔
Non-Shockable Epinephrine timing	3/3 (100%)	4/4 (100%)	↔
Epinephrine dose	3/3 (100%)	4/4 (100%)	↔

Bold arrows indicate 100% concordance.

Table 3: ILCOR council members' paediatric guideline concurrence with CoSTR recommendations

Council member	Basic Life Support: concurrence/no of items (%)			Advanced Life Support: concurrence/no of items (%)		
	2010	**2015**	**Direction of alignment**	**2010**	**2015**	**Direction of alignment**
American Heart Association	3/4 (75%)	3/4 (75%)	↔	7/10 (70%)	9/10 (90%)	↑
Australian and New Zealand Committee on Resuscitation	3/4 (75%)	4/4 (100%)	**↑**	9/10 (90%)	10/10 (100%)	**↑**
European Resuscitation Council	4/4 (100%)	4/4 (100%)	**↔**	10/10 (100%)	10/10 (100%)	**↔**
Resuscitation Council of Asia	N/A	N/A		N/A	N/A	
Resuscitation Council of Southern Africa	3/4 (75%)	4/4 (100%)	**↑**	5/5 (100%)	10/10 (100%)	**↔**

N/A = not available. **Bold arrows** indicate 100% concordance

Table 4: ILCOR council members' adult CPR guideline concurrence with CoSTR recommendations

Council member	Basic Life Support: concurrence/no of items (%)			Advanced Life Support: concurrence/no of items (%)		
	2010	**2015**	**Direction of alignment**	**2010**	**2015**	**Direction of alignment**
American Heart Association	4/4 (100%)	4/4 (100%)	**↔**	9/10 (90%)	9/10 (90%)	↔
Australian and New Zealand Committee on Resuscitation	4/4 (100%)	4/4 (100%)	**↔**	10/10 (100%)	10/10 (100%)	**↔**
European Resuscitation Council	4/4 (100%)	4/4 (100%)	**↔**	10/10 (100%)	9/10 (90%)	↓
Resuscitation Council of Asia	4/4 (100%)	4/4 (100%)	**↔**	N/A	N/A	
Resuscitation Council of Southern Africa	4/4 (100%)	4/4 (100%)	**↔**	5/5 (100%)	10/10 (100%)	**↔**

N/A = not available. **Bold arrows** indicate 100% concordance

Supplementary Table 1 Paediatric Basic Life Support

	ILCOR consensus recommendations[6,9,12]	Level of evidence	American Heart Association[23,34] (Also used by HSFC and IAHF)	Australian and New Zealand Committee on Resuscitation[16,37]	European Resuscitation Council[15,29]	Resuscitation Council of Asia	Resuscitation Councils of Southern Africa[17, 27]
Rescue breaths before compressions 2010	Not reviewed in 2010 (2000: 2 slow breaths, 1 to 1.5 seconds per breath)	Class indeterminate	No. Compressions before rescue breaths	No. Start compressions immediately	Yes. 5 breaths	No Asia wide guidance available	No. If no pulse after pulse check deliver chest compressions first. If pulse but not breathing, give rescue breaths. Child 12-20/min (every 3-5 seconds)
Rescue breaths before compressions 2015	Give 5 initial rescue breaths before starting chest compressions	Very low quality	No. Compressions before rescue breaths	Yes. 2 breaths before compressions	Yes. 5 breaths before compressions	No Asia wide guidance available	Yes. 5 initial rescue breaths before compressions if Paediatric BLS knowledge. If no Paediatric BLS training, use Adult BLS sequence
Chest compressions to ventilations ratio 2010	30:2 for lone rescuer. 15:2 for 2 healthcare provider CPR. Once tracheal tube is in place, compressions should not be interrupted for ventilations	LOE 5	30:2 for 1 rescuer. 15:2 for 2 rescuers. Infant: Lay rescuer use 2 fingers. Child: Lay rescuer use one or two hand method. Two rescuers: Use 2-thumb-encirculating hands technique	30:2. Infants: 2 fingers technique. Children: either a one or two hand technique. 1 or 2 hands if age >1 year	30:2 for single rescuer. 15:2 for 2 rescuers. 2 fingers if age < 1 year	No Asia wide guidance available	30:2 for 1 rescuer. 15:2 for 2 rescuers
Chest compressions to ventilations ratio 2015	Start at a ratio that is familiar to most (30:2). 15:2 for those who have the potential to resuscitate children as part of their role (i.e. trained personnel)	Very low quality	30:2 for 1 rescuer. 15:2 for 2 rescuers	30:2. Infants: Two thumb technique for delivering compressions to an infant. Either 1 or 2 handed technique to deliver	15:2 Infants: Use tips of 2 fingers if lone rescuer. If 2 rescuers, use encircling technique. >1 year: Use 1 or 2	No Asia wide guidance available	30:2 for 1 rescuer. 15:2 for 2 rescuers. Continuous chest compressions if unable to do breaths

				compressions to children	hands		
Chest compression depth 2010	At least a third of chest diameter or approximately 4cm for most infants or approximately 5cm for most children	LOE 4-5	'Push hard' with sufficient force to depress at least a third of AP diameter of the chest. Approximately 4cm in infants and 5cm in children	Depress the lower half of the sternum by approximately one third of the depth of the chest. Approximately 4cm in infants and 5cm in children	At least a third of chest diameter or approximately 4cm for infants or approximately 5cm for children	No Asia wide guidance available	Push hard. Ensure full chest recoil. Minimise interruptions
Chest compression depth 2015	At least a third of chest diameter or approximately 4cm for infants or approximately 5cm for children	Very low quality	At least a third of AP diameter of the chest. This equates to approximately 4cm in infants to 5cm in children. Once child has reached puberty, use adult compression depth of at least 5cm but no more than 6cm for the adolescent of average adult size	Should be approximately a third of the AP diameter of the chest. Approximately 4cm in infants and 5cm in children	At least a third of the AP diameter of the chest	No Asia wide guidance available	Push hard. Ensure full chest recoil. Minimise interruptions
Rate of chest compressions 2010 (compressions/ minute)	Not reviewed in 2010 (2000: Approximately 100/min)	Class IIb	At least 100/min	Approximately 100/min	100-120/min	No Asia wide guidance available	>100/min (almost 2 compressions per second)
Rate of chest compressions 2015 (compressions/ minute)	100-120/min	Very low quality	100-120/min	100-120/min	100-120/min	No Asia wide guidance available	Compress the chest fast (almost 2 compressions per second)

Key: /min = per minute; AP = Antero-posterior; LOE = level of evidence (range is from 1: randomised controlled trials to 5: studies not directly related to patient/population). 2010 Levels of Evidence (LOE) = LOE 1: Randomized controlled trials (RCTs) (or meta-analyses of RCTs); LOE 2: Studies using concurrent controls without true randomization (e.g., "pseudo"-randomized); LOE 3: Studies using retrospective controls; LOE 4: Studies without a control group (e.g., case series); LOE 5: Studies not directly related to the specific patient/population (e.g., different patient/population, animal models, mechanical models, etc.). 2015 GRADE quality assessment = Very low quality: the true effect is probably markedly different from the estimated effect; Low quality: the true effect might be markedly different from the estimated effect

Supplementary Table 2 Adult Basic Life Support

	ILCOR consensus Recommendations [8,10]	Level of evidence	American Heart Association [21, 32] (Also used by HSFC and IAHF)	Australian and New Zealand Committee on Resuscitation[16,37]	European Resuscitation Council[19,30]	Resuscitation Council of Asia[36]	Resuscitation Councils of Southern Africa[25, 27]
Rescue breaths before compressions? 2010	No. Rescuer encouraged to deliver rescue breaths after initial 30 compressions. If trained and choosing to deliver rescue breaths, give over 1second and deliver 2 breaths	LOE 5	No. Encouraging Hands-only (Chest compression only) CPR for the untrained lay-rescuer	No. Deliver chest compressions before breaths	No. If breathing is not normal or absent, start chest compressions	No Asia wide guidance available	No. If no pulse after pulse check, deliver chest compressions first. If pulse but not breathing, give rescue breaths at rate of 10/min (every 6 seconds)
Rescue breaths before compressions? 2015	CPR should begin with giving chest compressions rather than opening the airway and delivering rescue breaths.	Very low quality	No. Initiate CRP with chest compressions	No. Deliver chest compressions before breaths	No. Deliver chest compressions before breaths	No. Start compressions immediately	No. If no pulse after pulse check deliver chest compressions first. If pulse but not breathing, give rescue breaths every 6 seconds
Chest compression to ventilations ratio 2010	30:2 if no advanced airway	LOE 3-5	30:2	30:2 before the airway is secured	30:2	No Asia wide guidance available	30:2
Chest compression to ventilations ratio 2015	30:2	Low quality	30:2 if no advanced airway and a trained lay rescuer	30:2	30:2	30:2 if trained, able and willing, give recue breaths	30:2 (If unable to perform breaths, do continuous compressions until equipment arrives)
Chest compression depth 2010	Push hard and press down on the sternum	LOE 5	Push hard and fast At least 5cm	Depress the lower half of the sternum by approximately one third of the depth of the chest.	Push hard to a depth of at least 5cm (but not exceeding 6cm)	No Asia wide guidance available	Push hard. Ensure full chest recoil. Minimize

	to a depth of 5-6cm			Approximately 5cm in adults			interruptions
Chest compression depth 2015	Position your shoulders vertically above the victims chest and press down on the sternum to a depth of 5-6cm	Low quality	At least 5cm for an average adult. Avoid excessive chest compression depths greater than 6cm	At least one third of the depth of the chest (Approximately 5cm)	Press down on sternum, approximately 5cm (but not more than 6cm)	Push Hard. Approximately 5cms, no more than 6cm	Push hard. Ensure full chest recoil. Minimize interruptions
Rate of chest compressions 2010 (compressions/ minute)	At least 100/min	LOE 4	At least 100/min	Approximately 100/min	Rate of at least 100/min (but not exceeding 120/min)	No Asia wide guidance available	>100/min (Almost 2 compressions/second)
Rate of chest compressions 2015 (compressions/ minute)	100-120/min	Very low quality	100-120/min	100-120/min	100-120/min	Push fast at a rate of 100-120/min	Compress the chest fast (almost 2 per second)

Key: CPR = Cardio-Pulmonary Resuscitation; /min = per minute. 2010 Levels of Evidence (LOE) = LOE 1: Randomized controlled trials (RCTs) (or meta-analyses of RCTs); LOE 2: Studies using concurrent controls without true randomization (eg, "pseudo"-randomized); LOE 3: Studies using retrospective controls; LOE 4: Studies without a control group (eg, case series); LOE 5: Studies not directly related to the specific patient/population (eg, different patient/population, animal models, mechanical models, etc). 2015 GRADE quality assessment = Very low quality: the true effect is probably markedly different from the estimated effect; Low quality: the true effect might be markedly different from the estimated effect.

Supplementary Table 3: Paediatric Advance Life Support

	ILCOR consensus recommendations [6, 11, 9]	Level of evidence	American Heart Association[24, 35] (Also used by HSFC and IAHF)	Australian and New Zealand Committee on Resuscitation[13, 28]	European Resuscitation Council[15, 29]	Resuscitation Council of Asia	Resuscitation Councils of Southern Africa[20, 39]
Rescue breaths before compressions 2010	Not reviewed in 2010 (1997: 2-5 breaths at approximately 1.5 seconds per breath, 12 breaths/minute)	General consensus	No	Yes. 2 breaths	Yes. 5 breaths	No Asia wide guidance available	If pulse present but not breathing, give breaths every 12-20/min (Every 3-5 seconds). If no pulse, go directly to chest compressions
Rescue breaths before compressions 2015	Give 5 initial rescue breaths before starting chest compressions	Very low quality	No	Yes. 2 breaths	Yes. 5 breaths	No Asia wide guidance available	If pulse but no effective breathing, give rescue breaths; Infant every 4 seconds, child every 5 seconds
Chest compression to ventilation ratio 2010	30:2 for lone rescuer. 15:2 for 2-person rescue. Deliver uninterrupted once definitive airway in place	LOE 5	If no advanced airway, deliver 15:2. If advanced airway, 8-10breaths/min with continuous chest compressions	15:2	30:2 for lone rescuer. 15:2 for 2-person rescue. Rescuers with a duty to respond to the resuscitation of children should learn and use a 15:2 ratio. Uninterrupted once definitive airway in place	No Asia wide guidance available	30:2 for 1 rescuer. 15:2 for 2 rescuers
Chest compression to ventilation ratio 2015	Start at a ratio that is familiar to most (30:2). 15:2 for those who have the potential to resuscitate children as part of their role (i.e. trained personnel)	Very low quality	15:2 if no advanced airway	15:2	15:2. Uninterrupted once the airway is protected by tracheal intubation	No Asia wide guidance available	30:2 for 1 rescuer. 15:2 for 2 rescuers
Chest compression depth 2010	At least a third of chest diameter or approximately 4cm for most infants or approximatel	LOE 4-5	At least a third of AP diameter or approximately 4cm infants or approximately 5 cm children	At least one third of the AP dimensions of the chest or approximately 5cm in children or approximately	At least a third of chest diameter or approximately 4 cm for infants or approximately 5cm for	No Asia wide guidance available	Push hard. Ensure full chest recoil. Minimize interruptions

	y 5cm for most children			4cm in infants	children		
Chest compression depth 2015	At least a third of chest diameter or approximatel y 4cm for infants or approximatel y 5cm for children	Very low quality	Push hard At least a third of AP diameter of chest Allow complete recoil	Should be approximately a third of the AP diameter of the chest (approximately 4cm in infants, 5cm in children)	At least a third of chest diameter or approximately 4 cm for infants or approximately 5cm for children	No Asia wide guidance available	Push hard. Ensure full recoil. Minimise interruptions.
Rate of chest compressions 2010 (compressions / minute)	Not reviewed (1997: Approximatel y 100/min)	General consensus	At least 100/min	100/min	100-120/min	No Asia wide guidance available	>100/min
Rate of chest compressions 2015 (compressions / minute)	100-120/min	Very low quality	Push fast at 100-120/min	100-120/min	100-120/min	No Asia wide guidance available	100-120/min
Ventilation rate 2010 (breaths/ minute)	Not reviewed (1997: Initially: 2-5 breaths at approximatel y 1.5 sec/ breath. Subsequently: 20 breaths/min or 12/min for older child)	General consensus	8-10/min	10/min with LMA/bag valve mask. 12-14/min with ET tube	Once airway is protected by tracheal intubation, continue at 10-12/min without interrupting chest compressions	No Asia wide guidance available	Not on algorithms
Ventilation rate 2015 (breaths/ minute)	Once trachea is intubated and compressions are uninterrupted use a rate of approx. 10-12/min	Very low quality	Once advanced airway in place, give 1 breath every 6 seconds (10/min) with continuous chest compressions	Following intubation, deliver ventilation at 10/min	Once airway is protected by tracheal intubation, continue at 10/min without interruption	No Asia wide guidance available	1 breath every 6 seconds if advanced airway. Avoid excessive ventilation
Sh. Energy 2010	An initial dose of 2-4J/kg is reasonable for paediatric defibrillation. Higher subsequent doses may be safe and effective	LOE 3-5	First shock 2 J/kg, second shock 4J/kg. Subsequent shocks >4J/kg. Maximum 10J/kg or adult dose	If under 8 years old: 4J/kg or dose attenuated to 50J. If over 8 years old: may be treated with adult AED pre-set energy levels	4J/kg using preferably a biphasic waveform, but monophasic is also acceptable for first a subsequent shocks	No Asia wide guidance available	4J/kg first and subsequent shocks
Sh. Epinephrine timing 2010	Not reviewed (1997: After third shock and after subsequent three shocks)	Local availability and custom	After second shock and then repeat every 3-5 minutes	After second shock (then every second cycle)	Every 3-5 minutes after third shock	No Asia wide guidance available	Not on algorithms

Sh. Amiodarone 2010	May be used for the treatment of shock-refractory or recurrent VF/pulseless VT in infants and children	LOE 2-5	5 mg/kg bolus IV/IO. May repeat twice up to 15mg/kg Maximum single dose 300mg	5 mg/kg bolus which may be repeated	5 mg/kg after third shock and after fifth shock if continues to have a shockable arrhythmia	No Asia wide guidance available	Not on algorithms
Sh. Energy 2015	Give one shock of 4J/kg if using a manual defibrillator. If using an AED for a child over 8 years, use adult shock energy. If using an AED for a child <8years, deliver a paediatric attenuated adult shock energy.	Very low quality	First shock 2J/kg then 4J/kg. Second shock 4J/kg. Subsequent shocks 4J/kg. Maximum 10J/kg or adult dose	4J/kg for all shocks, preferably biphasic or monophasic shock for VF and pulseless VT	4J/kg using preferably a biphasic waveform, but monophasic is also acceptable for first a subsequent shocks	No Asia wide guidance available	4J/kg
Sh. Epinephrine timing 2015	After second shock Repeat every 3-5minutes	Very low quality	After second shock and then repeat every 3-5 minutes	Intervals of every 4 minutes (or every second loop)	Repeat every 3-5minutes(i.e. every second cycle)	No Asia wide guidance available	Every 3-5 minutes
Sh. Amiodarone 2015	5mg/kg bolus. May repeat up to two times for refractory VF/pulseless VT	Very low quality	5mg/kg bolus during cardiac arrest. May repeat up to two times for refractory VF/pulseless VT	5mg/kg bolus after third shock, then fifth shock	5 mg/kg after third shock and after fifth shock if continues to have a shockable arrhythmia	No Asia wide guidance available	5mg/kg dose
Non-Sh. Epinephrine timing 2010	Not reviewed (1997: not specified but suggests limiting to two doses)	Local availability and custom	Immediately then repeat every 3-5 minutes	Immediately (then every second cycle)	Immediately, then repeat every 3-5minutes (Every second loop)	No Asia wide guidance available	Not on algorithms
Non-Sh. Epinephrine timing 2015	Immediately, then every 3-5 minutes	Very low quality	Immediately, then repeat every 3-5 minutes	Immediately, then every 4 minutes (or every second loop)	Immediately, then repeat every 3-5minutes (Every second cycle)	No Asia wide guidance available	Every 3-5 minutes

Epinephrine dose 2010	Appropriate dose IV is 10 mcg/kg per dose (0.01 mg/kg) for the first and subsequent doses. The maximum single dose is 1 mg. If administered via tracheal tube in cardiac arrest, recommended dose is 0.1mg/kg	LOE 1-5	IV/IO: 0.01mg/kg (0.1ml/kg 1:10,000). Maximum dose 1mg. ET Tube: 0.1mg/kg (0.1ml/kg 1:1000) Maximum dose 2.5mg	10mcg/kg. Max single dose 1mg. ET Tube dose 100mcg/kg	IV or IO: 10mcg/kg (0.1ml/kg of 1 in 10,000 solution). Through tracheal tube (not recommended) : 100mcg/kg. Max single dose 1mg.	No Asia wide guidance available	Not on algorithms
Epinephrine dose 2015	IV is 10 mcg/kg per dose (0.01 mg/kg) for the first and subsequent doses. The maximum single dose is 1 mg.	Very low quality	IV or IO: 0.01mg/kg (0.1mL/kg of 1:10000 concentration). If no IV/IO access, may give ET dose: 0.1mg/kg	IV or IO: 10mcg/kg. Maximum single dose of 1mg ET Tube dose 100mcg/kg	IV or IO: 10 mcg/kg to a maximum of 1mg (0.1ml/kg in 1:10,000 solution)	No Asia wide guidance available	IV or IO: 0.01mg/kg

Key:/min = per minute; AP = anteroposterior; LMA = ET = Endotracheal; Sh = Shockable; J/kg = joules per kilogram; mg/kg = milligrams per kilogram; IV = Intra-venous; mcg/kg = micrograms per kilogram; J = Joules; IO = Intra-osseous; ml/kg = millilitres per kilogram; AED = Automated External Defibrillator; VF = Ventricular Fibrillation; VT = Ventricular Tachycardia; mg = milligram.
2010 Levels of Evidence (LOE) = LOE 1: Randomized controlled trials (RCTs) (or meta-analyses of RCTs); LOE 2: Studies using concurrent controls without true randomization (eg, "pseudo"-randomized); LOE 3: Studies using retrospective controls; LOE 4: Studies without a control group (eg, case series); LOE 5: Studies not directly related to the specific patient/population (eg, different patient/population, animal models, mechanical models, etc). 2015 GRADE quality assessment = Very low quality: the true effect is probably markedly different from the estimated effect; Low quality: the true effect might be markedly different from the estimated effect

Supplementary Table 4 Adult Advanced Life Support

	ILCOR consensus recommendations[7, 5]	Level of evidence	American Heart Association[22, 33] (Also used by HSFC and IAHF)	Australian and New Zealand Committee on Resuscitation[14, 38]	European Resuscitation Council[18, 31]	Resuscitation Council of Asia	Resuscitation Councils of Southern Africa[26, 39]
Rescue breaths before compressions 2010	No. Rescuer encouraged to deliver rescue breaths after initial 30 compressions. If trained and choosing to deliver rescue breaths, give over 1second and deliver 2 breaths	LOE 5	No	No	No	No Asia wide guidance available	No
Rescue breaths before compressions 2015	CPR should begin with giving chest compressions rather than opening the airway and delivering rescue breaths	Very low quality	No	No	No	No Asia wide guidance available	If pulse but no effective breathing, give rescue breaths every 6 seconds
Chest compression to ventilation ratio 2010	30:2 if no advanced airway	LOE 3-5	30:2 if no advanced airway. Continuous once an advanced airway is in place (ETT or SGA)	30:2 before the airway is secured	30:2. Continuous once advanced airway is in place	No Asia wide guidance available	30:2
Chest compression to ventilation ratio 2015	30:2	Low quality	30:2 if no advanced airway	30:2	30:2	No Asia wide guidance available	30:2
Chest compression depth 2010	Push hard and press down on the sternum to a depth of 5-6cm	LOE 5	Push hard (5cm)	Compress at least one third of the depth of the chest or at least 5cm for all adults	Minimise interruptions and ensure high quality compressions	No Asia wide guidance available	Push hard. Allow full recoil Minimize interruptions
Chest compression depth 2015	Position your shoulders vertically above the victims chest and press down on the sternum to a depth of 5-6cm	Low quality	Push hard (at least 5cm)	At least 5cm	At least 5cm but not more than 6cm	No Asia wide guidance available	Push hard. Ensure full chest recoil. Minimize interruptions
Rate of chest compressions 2010 (compressions/minute)	At least 100/min	LOE 4	Push fast, at least 100/min	At least 100/min	At least 100/min	No Asia wide guidance available	> 100/min

Rate of chest compressions 2015 (compressions/minute)	100-120/min	Very low quality	Push fast, 100-120/min	100-120/min	100-120/min	No Asia wide guidance available	Compress the chest fast. Rate100-120/min (Almost 2 per second)
Ventilation rate 2010 (breaths/minute)	Ventilation rate of 8-10/min once an advanced airway is in place	LOE 5	One breath every 6-8 seconds (= 8-10/min)	6-10/min with an advanced airway in place	10/min once the patient's trachea has been intubated or a SGA Device has been inserted	No Asia wide guidance available	10/min (every 6 seconds)
Ventilation rate 2015 (breaths/minute)	Ventilation rate of 10/min once an advanced airway is in place	Very low quality	After placement of an advanced airway, deliver 1 breath every 6 seconds (10/min) whilst continuous chest compressions are being performed	6-10/min	10/min once the patient's trachea has been intubated	No Asia wide guidance available	Avoid excessive ventilation; 1 breath every 6 seconds if advanced airway
Sh. Energy 2010	Biphasic shock: at least 150J. Monophasic: 360J	LOE 4	Biphasic: Use manufacturer's recommendation - if unknown use maximum available. Second and subsequent doses should be equivalent and higher doses may be considered Monophasic: 360J	Biphasic initial shock 150J. For pulsed biphasic begin at 120-150J. Second shock 150-360J biphasic	Initial shock 150-200J biphasic or 360J monophasic. Subsequent shocks 150-360J biphasic, 360J monophasic.	No Asia wide guidance available	Not on algorithms
Sh. Epinephrine timing 2010	After third shock and repeat every 3-5 minutes	LOE 4-5	After second shock, then every 3-5 minutes	Every 3-5 minutes after third shock once compressions have restarted	Every 3-5 minutes	No Asia wide guidance available	Not on algorithms
Sh. Amiodarone 2010	After third shock. First dose 300mg bolus. Second dose 150mg IV/IO	LOE 4-5	First dose 300mg after third shock. Second dose 150mg	300mg after third shock	300mg after third failed defibrillation attempt	No Asia wide guidance available	Not on algorithms
Sh. Energy 2015	Follow manufactures instructions. Recommend initial biphasic	Very low quality	Biphasic: Use manufacturer's recommendation - if	Biphasic initial shock 150J. For pulsed biphasic begin at 120-150J.	For biphasic use initial shock 150J. For pulsed biphasic begin	No Asia wide guidance available	Give 1 shock. Biphasic 120-360J. Monophasic 360J

	energy of 150-200J or 360J for monophasic		unknown, use max available. Second and subsequent doses should be equivalent and higher doses may be considered. Monophasic 360J	Second shock 150-360J biphasic	at 120-150J. Subsequent shocks 150-360J biphasic.		
Sh. Epinephrine timing 2015	After third shock and then every 3-5 minutes	Low quality	After second shock. Then every 3-5 minutes	Give every 3-5 minutes	After second shock and then every alternate cycle	No Asia wide guidance available	Every 3-5 minutes
Sh. Amiodarone 2015	300mg, given after third shock. Consider a second dose of 150mg after the fifth shock	Moderate quality	300mg bolus after third shock. Second dose 150mg	300mg after third shock. Further dose of 150mg may be given after the fifth shock	300mg after the third failed attempt at defibrillation	No Asia wide guidance available	300mg followed by 150mg
Non-Sh. Epinephrine timing 2010	Give as soon as IV access is achieved and continue every 3-5 minutes	LOE 4-5	Immediately, then every 3-5 minutes	Every 3-5 minutes (every second cycle)	Immediately, then every second loop (approximately every 3-5 minutes)	No Asia wide guidance available	Not on algorithms
Non-Sh. Epinephrine timing 2015	Give as soon as feasible as IV access achieved, and continue every 3-5 minutes	Low quality	Immediately, then every 3-5minutes	Every 3-5 minutes (every second cycle)	Immediately, then every alternate cycle (approximately every 3-5 minutes)	No Asia wide guidance available	Every 3-5 minutes
Epinephrine dose 2010	1mg IV or IO. Delivery of drugs via ET Tube no longer recommended	LOE 1	1mg IV or IO ET Tube route 2-2.5mg	1 mg IV or IO. Delivery of drugs via ET Tube is no longer recommended	1 mg IV or IO. Adrenaline can be given via ET Tube route at a dose 3-10 times IV/IO dose	No Asia wide guidance available	Not on algorithms
Epinephrine dose 2015	1mg IV or IO	Low quality	1mg IV or IO	1mg IV or IO	1mg IV or IO	No Asia wide guidance available	1mg IV or IO

Key: /min = per minute; Sh = Shockable; J = Joules; IV = Intravenous; IO = Intra-osseous; mg = milligrams; ET = Endo-tracheal; SGA = Supraglottic airway. 2010 Levels of Evidence (LOE) = LOE 1: Randomized controlled trials (RCTs) (or meta-analyses of RCTs); LOE 2: Studies using concurrent controls without true randomization (eg, "pseudo"-randomized); LOE 3: Studies using retrospective controls; LOE 4: Studies without a control group (eg, case series); LOE 5: Studies not directly related to the specific patient/population (eg, different patient/population, animal models, mechanical models, etc). 2015 GRADE quality assessment = Very low quality: the true effect is probably markedly different from the estimated effect; Low quality: the true effect might be markedly different from the estimated effect; Moderate quality: the authors believe that the true effect is probably close to the estimated effect.