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Does electronic decision support influence advanced life support in simulated cardiac arrest?

TITLE

Does the introduction of an electronic decision support system influence the delivery of advanced life support in a simulated cardiac arrest scenario? A proof of concept study

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ABSTRACT

Introduction

In-hospital Cardiac arrest is common but despite mandatory resuscitation training for staff, the survival rates vary considerably. The reason for such variation is unclear but may relate to a number of human factors. Decision support systems and tools have been suggested as a means of reducing human errors and improve patient outcome. In this proof of concept study, we tested the use of such a device in a simulated environment

Methods

The aims of this study were firstly, to investigate if the introduction of an electronic decision support system (eDSS) influenced the delivery of advanced life support in a simulated cardiac arrest scenario and secondly, to explore the users' views on their performance both with and without the eDSS.

Twenty-nine registered and five student nurses made up eight cardiac arrest teams. Adopting a cross over design, each team managed two comparable in-hospital cardiac arrest scenarios with and without the use of an electronic decision support system. Use of the device was alternated to minimise bias. During each cardiac arrest scenario, a researcher documented the teams' adherence to the ALS protocol with a standardised checklist. Immediately following the completion of the scenarios, each team participated in a group interview to explore their perceptions of their performance and their use of the decision support system.

Data analysis

Due to the small numbers involved in this proof of concept study, the quantitative results are presented as raw data and no inferences are made. The qualitative data generated from the interviews were independently analysed by two members of the research team adopting Braun and Clarke's framework for thematic analysis[1].

Results

When using traditional means we witnessed one missed and one delayed shock and five drug omissions. When using the eDSS, patients were defibrillated at the correct times but three of the shocks were unsafe. There was also one missed and four delayed drug administrations.

The qualitative interviews yielded one overarching theme- team working. Three sub themes included team performance and dynamics, team leader performance and areas for development. Some considered the device to support organisation and be a source of reassurance, whereas others thought of it as a distraction, articulating the need for greater familiarity.

Discussion

Our findings are aligned with those of previous studies. Teams using the decision support system were more likely to adhere to the drug and shock administration elements required by the ALS protocol but were less safe in doing so. We suggest that this may have occurred due to unfamiliarity with the software after only a short orientation. Therefore, future studies should ensure participants are comfortable using the device prior to testing.

The participants viewed team leaders positively despite clear breaches of protocol. This positivity was based on the perceived communication and organisation of the event rather than protocol adherence, demonstrating the futility of self-reporting in critical situations.

The eDSS was well received by most. Some staff felt supported using the eDSS and believed that its use aided organisation and communication. Conversely, some staff felt that the software was distracting.

Conclusion

An electronic decision support system offered support to those managing a simulated cardiac arrest through a perceived feeling of safety and reassurance with greater adherence to protocol, including fewer missed drugs. However, reduced situational awareness was observed when the software was used. This may have occurred due to unfamiliarity with the device, which could be improved with increased usage. Moreover, these findings highlight the importance of testing prototypes in extensive simulation-based situations before being used in the clinical arena.

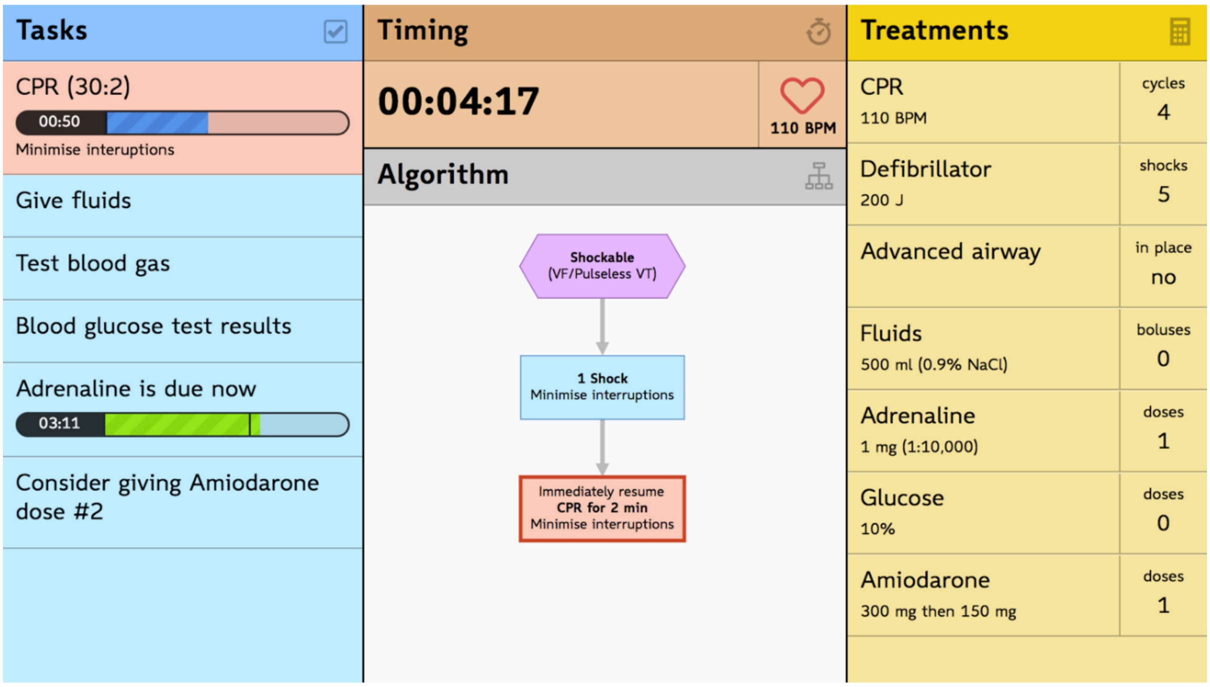
INTRODUCTION

Cardiac arrest in a hospital setting is common and results in around four out of five patients not surviving to hospital discharge [2]. Survival rates vary considerably both nationally and internationally [3]. The reasons for this are complex but may include inappropriate treatment choices, poor coordination and lack of communication [2]. In an attempt to reduce these variations, the International Liaison Committee on Resuscitation (ILCOR) produce standardized treatment algorithms, updated every five years that guide the clinician when faced with a cardiac arrest. Clinicians often manage these highly stressful situations by relying on their ability to recall these algorithms from memory. It is therefore unsurprising that those same clinicians are prone to error and often fail to provide optimal care [4, 5, 6, 7]. Nurses are often the first professionals to respond to cardiac arrest and perceive themselves to be competent in managing these events [8,9]. However, such confidence may be misplaced with many nurses failing to retain their knowledge and skills over time [10].

A number of human factors have been identified that compromise patient safety during cardiac arrest which include poor leadership, task overload, poor communication, lack of mutual performance monitoring and lack of adherence to guidelines [11]. Decision support systems and tools, have been proposed as a means of removing, or at least limiting, these human factors [11]. Such aids are used commonly in the aviation industry to minimize risk during stressful events such as take-off and landing [12]. However, their usage in healthcare settings continues to be debated. Whilst some studies [13, 14, 15, 16, 17] have found that using a decision support tool improves guideline adherence, others [12, 18] have noted that the use of aids leads to impaired performance. However, these negative results can be explained by a combination of a lack of familiarity with the aid [18], which resulted in treatment delay, and the use of multiple aids [13], causing confusion. These two studies highlight some of the problems with decision support system development, that is, they need to be a single point of reference, user friendly and intuitive. Producing an effective eDSS is therefore impossible without formal user engagement and feedback during the design stage.

In collaboration with a selection of selection of doctors, nurses and other practitioners involved in resuscitation, TeamScreen, an electronic decision support system (eDSS) to support the management of in-hospital cardiac arrest (Fig 1) was developed. The "co-creation" process involved incorporating the feedback of study participants into modifications of the system before testing with subsequent groups. The development of the app was undertaken with a combination of doctors, nurses and resuscitation officers prior to testing in this study

Fig 1



This software, controlled by a hand-held tablet device, guides the clinician through the advanced life support process, providing prompts when treatment is due or overdue. Other members of the cardiac arrest team are able to observe the progression of events in real time on a large screen. We believed that the introduction of this novel electronic system would reduce the human factors outlined by Anderson and colleagues (2010) [11]. In addition, it may also enhance adherence to protocols in crises as some studies have shown [16,19,20]. We therefore tested this hypothesis and gained end user feedback through a simulation-based cross-over proof of concept study.

Study Aim:

Does the introduction of an electronic decision support system influence the delivery of advanced life support in a simulated cardiac arrest scenario?

Objectives:

- Does the introduction of an electronic decision support system improve nurses' adherence to the advanced life support algorithm during a simulated cardiac arrest?

- How do nurses perceive their performance when delivering a simulated advanced life support scenario both with and without an electronic decision support system?

Methods

Study population

We recruited 34 participants from Liverpool John Moores University's School of Nursing and Allied Health's alumni database. Five were student nurses and 20 were registered nurses who had been involved in a hospital cardiac arrest and completed an active basic life support qualification within the past 12 months. Eight held an ALS qualification and were assigned to the team leader role, which ensured an ALS-certified nurse led all teams

Eight cardiac arrest teams were constructed from the total sample (34) with four respondents participating on more than one occasion. One of these repeating respondents was a student nurse, two were registered nurses with BLS qualification and the remaining respondent was a Registered Nurse team leader with an ALS qualification. This ALS certified participant led a team on two occasions. Each team consisted of either four or five participants. The study received ethical approval from the University Research Ethics and Governance Committee.

Study design

Individual teams attended the university's clinical simulation suite where they met their teammates, many of whom were meeting for the first time. The team leader was identified but no other roles were specified leaving the team leader to allocate roles and tasks. The team were allowed a short time to familiarise themselves with the simulation and cardiac arrest equipment and were given a 5 minute presentation on the use of the eDSS by a researcher.

The team were then observed delivering two ALS scenarios. The scenarios, based on UK resuscitation guidelines (Fig 2), were written and subsequently reviewed by two independent ALS instructors.

Adopting a crossover design, as outlined in fig 3, each team managed two comparable in-hospital cardiac arrest scenarios, with and without the use of an electronic decision support system (TeamScreen). This approach was used to reduce the risk of order effects. The Laerdal Resusci Advanced Skill Trainer manikin was used and standard resuscitation equipment was available.

Fig 2
The two scenarios used were as follows:

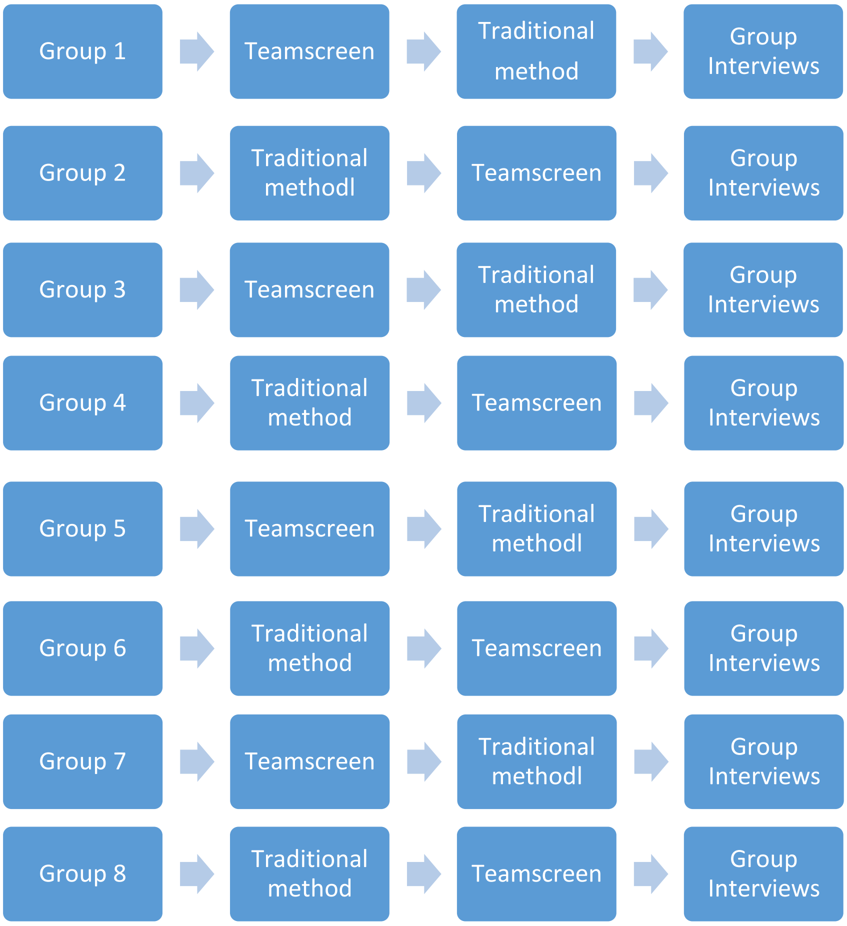
Scenario 1
S: You are the nursing team on an acute medical ward, called over to the bed by the patient's wife.
B: 51-year-old patient complaining of chest pain and shortness of breath. History of MI.
A: He seems to be less responsive and breathing looked laboured.
R: Emergency assessment required

Patient in VF for 5 cycles before ROSC.

Scenario 2
S: You are the nursing team in the emergency department.
B: 65-year-old heavy smoker admitted with dizziness and pain going down the left arm.
A: His wife tells you that she cannot wake him up.
R: Can you come and have a look at him please?

Patient in PEA for 2 cycles and 3 cycles VF before ROSC.

Fig 3



Immediately following the completion of the scenarios, each team participated in a group interview as outlined to explore their experiences of delivering the scenarios in Fig 3.

Data Collection

A researcher observed each 15-minute scenario. The researcher documented the teams' adherence to the ALS protocol, with a standardised checklist.

Immediately following the scenarios, the participants took part in a group interview, lasting on average 30 minutes. We used open-ended questions to explore their perceptions of the delivery of advanced life support both with and without the eDSS.

Results

Objective 1- Adherence to protocol

Due to the small numbers involved in this proof of concept study, the results are presented as raw data.

When using the eDSS, participants defibrillated the patient at the correct times (as outlined in the Resuscitation Council (UK) guidelines (2015)[21] throughout all eight scenarios compared with one missed and one delayed shock when the software was not used. However, when using the eDSS, two of the participants failed to ensure that the immediate patient area was cleared of personnel and therefore delivered three unsafe shocks. This compares to no unsafe shocks when relying on traditional methods (Fig 4).

When looking at drug errors, we found that four of the six instances where drugs were delayed occurred when the eDSS was used and five of the six instances where the drugs were incorrectly omitted occurred when using the traditional approach.

Fig 4

SHOCKS	MISSED	DELAYED	UNSAFE
WITH eDSS	0	0	3
WITHOUT eDSS	1	1	0
	MISSED DRUG	**DELAYED DRUG**	UNSAFE (wrong dosage)
WITH eDSS	1 adrenaline	2 adrenaline 2 amiodarone	0
WITHOUT eDSS	4 adrenalin 1 amiodarone	1 adrenaline 1 amiodarone	0

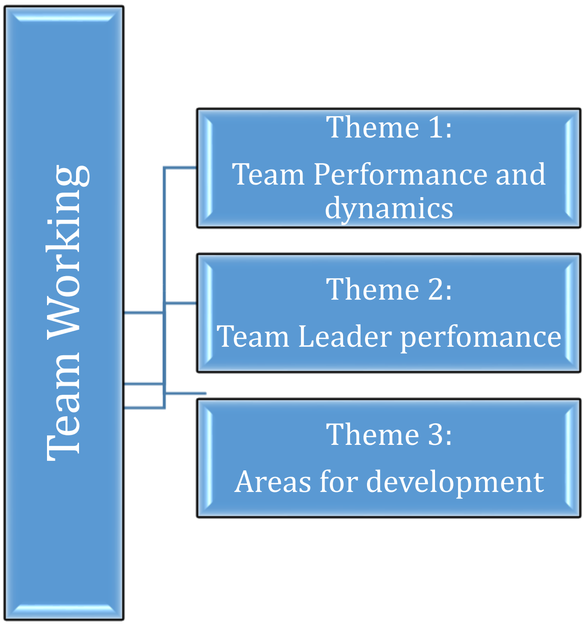
Objective 2 – Nurses perception of performance

Group interview

The data were independently analysed by two members of the research team adopting Braun and Clarke's (2006) [1] framework for thematic analysis.

Following this iterative qualitative data coding approach and analysis, one overarching theme emerged, Team Working. A further three themes emerged and are illustrated in the thematic map below (Fig 5)

Fig 5



Theme 1: Team Performance and dynamics

The participants were asked broad questions within the group interviews; commencing the interview with *'how do you feel that the scenario went?'* This instigated a discussion on the performance of the team. The participants discussed the team as a whole rather than analysing their own individual performances, their own technical skills or adherence to protocol. Therefore, participants were asked '*What do you think you did well as team?'* Overwhelmingly the groups all viewed their team performance positively. Comments included:

'*We worked well as a team'* **RI: FG1**
'I thought we were really good' **R2: FG3**

Moreover, during the interviews they frequently highlighted skills that they felt illustrated how they worked as a team. These included rapport, communication skills, confidence, calm approach, concise instructions and delegation.

'*Awareness of each other a team member'* **R1: FG3**
'We knew each other's names' **R1: FG3**
'
'I think it was the way we communicated and we took things in turn' **R4: FG1**
'Jobs, delegation… we all knew what we were doing' **R4: FG4**
'It was …Calm' **R4: FG5**

Only when the group attempted to deconstruct the team dynamics did a small amount of critical consideration emerge. This was noted when reflecting on the size of the groups, believing that the number of staff they had available potentially affected their performance. Conflict emerged within the discussion regarding the 'ideal' size of a group.

'Less people should be involved' **R1: FG1**
'If there were more people involved… it would be nice to hand over that defib' **R1: FG3**

This discussion suggests that the size of the group appears to influence the perceptions the participants held of the team's efficiency, with some suggesting that more group members would reduce task burden and lead to greater team efficiency. Conversely, others suggested that increased numbers of participants may be distracting and would negatively affect team performance. Importantly, whilst some group members suggested that five was the optimum number of staff needed in a cardiac arrest team, a consensus was not reached across the eight groups.

The group discussions extended to consideration of not only participants presence within the simulations but also the team members' level of experience. A number of team members considered the level of experience influential. Some participants suggested there was a need for team members to have specific experience and education and in particular, completion of the ALS course was considered advantageous to team efficiency.

'Another ALS [trained person] would be useful' **R2: FG4**

When asked to consider how, if at all, the eDSS influenced performance, individual views differed. Some felt that the eDSS improved communication and organisation. In particular, they noted that the presence of a visual schematic, that provided a real-time record of actions, enabled them to recognise their position within each cycle and ensure the timings of the action were in keeping with the protocol.

> *That was the good bit about it. Everyone knew where they were up to. How many shocks, how many cycles we were on, what medication had been given. That was the good bit. That was the good visual aspect* ***FG2 R1***
>
> *"Yeah so it was a good, it was definitely a good prompt and I personally found it useful and I felt that we had a tighter handle on the situation the first time than the second time". R3 FG2*

However, some considered the device distracting and could therefore impede team performance.

> *'We were kind of more concentrating in that (scenario without the use of the eDSS). In the second one (scenario with the use of the eDSS) we were kind of a little distracted because we are not used to that iPad and the screen'* **FG7 R4**
>
> *' I think it was just that it was the first time we were using the iPad and it was a bit distracting. That was the problem, I think, just the iPad'* **FG6 R2**
>
> *' I think we had more direction in the first scenario. Personally I put it down to the team being a bit distracted with the equipment'* **FG6 R4**

The teams also recognised that their recall of events can often be inaccurate and they believed that the eDSS would enable them to provide a more factual account of events.

> *And that's no disrespect to anyone cos it really is hard. By the time you've got to your cardiac arrest you've started and then someone gets a scrap piece of paper and pen and you're like have you put that adrenaline down and oh yeah****. FG4 R3***

Theme 2: Team Leader Performance

During the general discourse, surrounding *the opening question* the team leader's performance became a focus for examination. This performance was viewed positively by group members; focussing on their leadership skills rather than their adherence to the protocol

'We had a very good team leader' **R1:FG3**
'The nice thing was having a clear leader' **R1: FG5**
'She was clear and concise' **R3: FG2**

Conversely, the team leaders judged their performance against the published protocol, highlighting their own errors but failing to consider their leadership role within the team.

> '*I couldn't remember which cycle I was up to' (without use of eDSS)* **R2: FG1**
> '*As soon as you came out I said you gave the adrenaline in the wrong order' (without use of eDSS* **R3 FG4**

Some team leaders welcomed the use of the eDSS considering the system as a failsafe mechanism, and valuing its ability to provide the wider team with a real time visual schematic of events.

> *Yeah I felt more comfortable this time with it because it sort of felt like a safety net really R2 FG2*

> *I think at one point I wasn't looking at my iPad, and I think you (name), was like, 'Two minutes are up', and I was like, 'Oh God, yeah, two minutes are up'. So everyone can see when the two minutes are up.R3 FG3*

However, the distraction that has been highlighted above resulted in some team leaders experiencing a loss of control; as they became reliant on eDSS and by doing so lost situational awareness.

> *The second one (when eDSS used) was looking more at the board than the patient and thinking about what was actually going on. So I felt that lost that sort of control R1 FG2*

Theme 3: Areas for development

The participants were asked '*Were there any areas where you thought you could do better as a team?* Whilst team performance was viewed extremely positively, all groups noted areas for development. These included the team leaders' questioning their adherence to the protocol, recognising delays but challenging their recall of events.

> *'There was a delay wasn't there?'* **R4: FG1** when referring to the team leader's performance

The team identified practical issues such as the height of the bed but also errors in judgement and competency such as recognising rhythms and nearly 'shocking' a member of the team.

> '*So **(PARTICIPANTS NAME)** could have effectively got a shock in that event, because she was right at the bed space'* **R4: FG2**

Whilst others had previously valued the eDSS' ability to provide visual information, some team members felt that this information should be limited further with only the information required at the time being visible on the screen.

> *And, as I say, to start off with I think just a screen saying, 'Do CPR', and then it adds stuff … sort of like the algorithm itself. You don't need to look at the whole thing, you need to look at it in stages don't you? FG8 R1*

However, participants recognised that their lack of familiarity with the eDSS could have affected their performance, hypothesising that this may improve with greater usage..

> *But that could be because this is something that I would never do. I've obviously never done before, and if you used it again would it be different? Possibly because you'd be more used to it. It just felt very alien for something telling me what to do when I'm running an arrest. FG7 R5*

Discussion

Decision support systems and tools such as checklists and manuals have been used for some time to support the management of emergencies. They have been shown to enhance protocol adherence and improve overall performance [22, 12, 20, 23, 24, 25]. Our findings, whilst limited, are in keeping with those of previous studies. We noted that teams were more likely to adhere to the drug and shock administration elements required by the ALS protocol when using the eDSS, administering all required drug therapy and defibrillation. Conversely, some teams were less safe when using the eDSS, administering three unsafe shocks. The reasons for this are unclear and with limited numbers may be solely related to individual deficiencies. However, previous studies have found that using an eDSS reduces situational awareness, diverts the user's attention away from the patient, delays life-saving interventions [26] and increases the risk of misunderstandings [24]. In keeping with these findings, our participants suggested that they were distracted; such distraction may have been caused by a lack of familiarity with the software. The teams were given only a 5 min orientation to the eDSS and were not afforded an opportunity to practice using the software prior to enacting the scenario. This may have resulted in the team defaulting to what is familiar and ignoring what is unfamiliar.

Failures within teams and poor communication are among the most common reasons for adverse medical events [27,28]. Previous decision support tools were designed solely to support the team leader, failing to recognise the importance of effective communication and team cohesion, whereby team situational awareness could then be lost. Team Screen attempts to overcome this deficiency by relaying the team leader's actions onto a second large screen visible to the entire team. Other studies have found that decision support systems that support the whole team have the potential to enhance team performance, team communication and situational awareness. (28,29). Our participants, whilst accepting the merit of the second screen as a means of improving organisation and communication, some participants felt that the introduction of information resulted in loss of control and recommended that future devices should provide only the information that was required at that particular point in time.

Our participants perceived their team and team leader's performance positively, despite clear deviance and omissions from the protocol. Whilst team leaders judged their performance based on protocol adherence, team members focussed heavily on team dynamics as a measurement of success. The participants described how composed they were, the rapport they developed and how well tasks were delegated, failing to recognise fundamental omissions. Whilst we recognise that effective communication helps to establish and maintain the dynamics of an effective team [30] it is essential that teams deliver the actions outlined in the protocol. In addition, team leaders were unable to confirm whether they had adhered fully to the protocol and often requested confirmation from others, which was frequently falsely positive. This loss of situational awareness is well documented [31,32,33,34), particularly when immersed in complex or perceived stressful clinical situations [35,36] as individuals focus on the minutiae rather than the overall event. This lack of insight whilst concerning, is in keeping with previous published studies that have found, those that underperform overestimate their performance and high performers underestimate theirs [37] illustrating that self-reporting is neither a suitable means of measuring the quality of resuscitation performance nor should it be relied upon when recording medical interventions in patient records. Acknowledging this incongruity, the participants recognised that the eDSS would overcome the latter, providing a contemporaneous account of events ensuring that the proceedings recorded in the patient's medical record were a true reflection of the event.

The eDSS was generally well received. Participants valued the visual schematic and prompts that the device provided, feeling that the process was streamlined and more organised when the eDSS was used. Nevertheless, some felt that the device was distracting which we theorise may have been due to unfamiliarity. With this in mind, it is advisable that in future research the participants become proficient in the use of the device through a practice scenario prior to assessment. Furthermore, our findings highlight the importance of testing prototypes in extensive simulation-based situations like ours, before being used in the clinical arena

Conclusion

In the chaotic environment of a cardiac arrest, identification of error and other human factors is an important challenge [30]. There is an increasing body of literature to support the use of simulation to assess performance, and studies surrounding the use of decision support tools and systems in simulated critical situations are now emerging [38,39, 24, 27]. However, we have demonstrated that self-reporting of performance is misleading and should be avoided when studying such phenomenon. Moreover, such reporting, which is currently relied upon when documenting medical care, does not provide an accurate record of events.

We observed that a two-screen electronic decision support system (eDSS) offered support to those managing a simulated cardiac arrest through a perceived feeling of safety and reassurance with greater adherence to protocol. However, the use of this device resulted in team leaders losing a degree of situational awareness. This effect may have occurred as result of individual performance, unfamiliarity with the device or suboptimal device design.

Limitations:

Like many proof of concept studies, our results are limited by the small and uni-disciplinary nature of the sample. In addition, we recognise that participants' unfamiliarity with the device may have influenced their behaviour resulting in a less realistic experience. We also recognise that when consenting to participate in the study, the respondents were anticipating that they would be participating in a cardiac arrest scenario. They were therefore, unlike clinical practice, psychologically prepared for such an event. Moreover, we also recognise that the focus group approach, where participants of all grades were asked to provide their views may have influenced the data. However, generating proof of concept data and providing feedback as part of a learning cycle in the early stages is an essential component of product development and the findings are therefore worthy of discussion.

Recommendations

We would recommend and intend to undertake additional studies to explore the usage of electronic advanced life decision support systems. Those studies should include a large multi-professional sample who have an opportunity to use the device in practice-simulated situations prior to testing. Moreover, further studies are needed to explore the causes and contextual nature of reduced situational awareness so that such causes can be factored into product design and future training.

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Conflict of interest
Dr Hannah Lonsdale is the Clinical Director of Team Screen, Community Interest Company. Dr Lonsdale was involved in the product development and observed the simulation scenarios but had no involvement in any part of the assessment or interviews. The primary author had sole responsibility for the content of the final manuscript. No other member of the team has any conflict of interests

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