Closed-loop communication during out-of-hospital resuscitation

Cover Sheet

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Bionote

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Abstract and keywords

Abstract

Training for effective communication in high-stakes environments actively promotes targeted communicative strategies. One oft-recommended strategy is closed-loop communication (CLC), which emphasises three components – call-out, checkback, and closing of the loop – to signal understanding. Using CLC is suggested to improve clinical outcomes, but research indicates that medical practitioners do not always apply CLC in team communication. Our paper analyses a context in which speakers' linguistic choices are guided by explicit recommendations during training, namely out-of-hospital cardiac arrest (OHCA) resuscitation. We examined 20 real-life OHCA resuscitations to determine whether paramedics adopt CLC in the critical first five minutes after the arrival of the designated team leader (a paramedic specially trained in handling OHCA resuscitation), and what other related communication strategies may be used. Results revealed that standard form CLC was not consistently present in any of the resuscitations despite opportunities to use it. Instead, we found evidence of non-standard forms of CLC and closed-ended communication (containing the first two components of standard CLC). These findings may be representative of what happens when medical practitioners communicate in time-critical, real-life contexts where responses to directives can be immediately observed, and suggest that CLC may not always be necessary for effective communication in these contexts.

Keywords: closed-loop communication; out-of-hospital cardiac arrest resuscitation; paramedic team communication; dialogue annotation/dialogue coding

Title page

Title: Closed-loop communication during out-of-hospital resuscitation: Are the loops really closed?

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Manuscript

1.0 Introduction

There is a universal acceptance of the importance of effective communication in the medical domain and a growing agreement that miscommunication is a cause of adverse events. Medical miscommunication has been listed as one of the dominant causes of death and/or permanent loss of function (Joint Commission on Accreditation of Healthcare Organizations 2016). Ineffective communication is not only a concern in medical contexts, but also an issue in other ‘high-reliability’ fields like engineering and aviation (Flin *et al.* 2008). For instance, the Three Mile Island nuclear accident has been traced to non-optimal communication in letters prior to the incident, and a fatal collision between two Boeing 747 aeroplanes in 1977 has been revealed to be a result of miscommunication between a pilot and an air traffic controller (Riley 1993; Cushing 1994). The increased awareness of the importance of accurate and effective communication in high-risk domains has led to the development and implementation of various communication strategies designed to minimise the risk of unwanted outcomes.

1.1 The closed-loop communication strategy

A strategy often recommended for effective communication in high-risk domains is closed-loop communication, or CLC. This strategy calls for three distinct stages to confirm an exchange of information – the call-out, the checkback, and the closing of the loop. An ideally conducted, standard form CLC looks like the dialogue below:

Speaker:	John, could you get 20 ml saline solution?	Call-out
Addressee:	Okay Mark, I’ll get 20 ml saline solution.	Checkback
Speaker:	Thanks.	Closing the loop

In principle, CLC can guarantee the accuracy of information exchange. Miscommunication is common in verbal interactions and it can be caused by a lot of factors, but the act of verbally confirming what one understands from a message helps mitigate this risk since the speaker can immediately correct the addressee if their interpretation of the speaker's original message is inaccurate.

CLC is a communication behaviour found to be consistently present in effective military teams and has been utilised in commercial aviation intervention training called Crew Resource Management or CRM (Salas *et al.* 1999). Following CRM's success, the strategy has been actively advocated for in medical communication and training. Recommendations to apply CLC during medical procedures are clearly discernible in online manuals and guidelines like the one from the Victorian State Trauma System, Australia, which gives the following example for CLC in its Major Trauma Guidelines and Education section:

Speaker:	James, I want you to insert a large-bore IV, please
Addressee:	You want me to insert a 16-gauge IV?
Speaker:	Correct

Similar recommendations can be found in other training guidelines. A newsletter by ZOLL Medical Corporation shows the following as an example of CLC for medical staff:

Bob:	Give that kid a milligram of epi
Karen:	You mean 0.1 mg, right?
Bob:	Yes, a milligram, you know what I mean, Karen
Karen:	You mean 0.1 mg, of 1:1000 epinephrine, SC…right Bob?

Bob:		Yes, I'll write it down correctly, too

In research literature, CLC has been emphasised as a vital component in medical communication, especially with respect to maintaining team situational awareness. A medical procedure like surgery requires team members to perform different tasks, during which each member may not always have full knowledge of everything that occurs. Their actions and awareness therefore need to be coordinated effectively and explicitly to ensure a successful outcome. Gillespie *et al.* (2013) found that in cardiac surgery, where decisions and plans may be formulated independently by the team members, verbal confirmation of action is necessary to ensure that the surgery team is on the same page. When CLC is not applied, information is very likely to be lost. Parush *et al.* (2011) investigated team situation awareness and factors affecting information exchanges for situation awareness. They found that open-loop communication, non-directed loop communication, and communication involving delayed closure of the loop are highly susceptible to information loss, thereby emphasising the benefit for CLC in team communication in these contexts. Table 1 shows the description of each type of communication loop mentioned in the present study:

(insert Table 1)

In resuscitation, CLC has also been promoted as a valuable communication strategy, although studies that specifically assess the use and form of CLC in actual resuscitation settings are scarce. Castelao *et al.*'s (2013) review of 63 articles regarding the effect of team coordination on cardiopulmonary resuscitation outcomes established CLC as one of the recommended strategies for effective team coordination, but it should be noted that the vast majority of the reviewed articles were studies of medical simulations. More recently (and at the time of writing, the only intervention study linking CLC and actual resuscitation), El-Shafy *et al.* (2018) demonstrated that the use of CLC in neonatal resuscitation resulted in significant improvement of time-to-task completion. The researchers recorded 387 verbalised orders from trauma team leaders in the resuscitation room and identified CLC. Comparison of closed-loop and open-loop orders showed quicker time-to-task completion for the former.

Given its reported importance and effectiveness in high-risk contexts, it might be expected that CLC occurs frequently in medical settings. Studies showed that this is not the case. In 16 in situ trauma team training sessions that started with an introductory video emphasising the use of CLC, only 14% of call-outs resulted in CLC (Härgestam *et al.* 2013). This translated into fewer than three CLC exchanges on average in each team. Even El-Shafy *et al.* (2018) reported that only approximately 26% of the verbal orders in their study were closed-loop. In addition, there is also evidence that CLC is unfamiliar to medical personnel (Andersen *et al.* 2010), hence reducing its usage and usefulness. However, in a study regarding actual resuscitation in paediatric intensive care units, Taylor *et al.* (2014) found that 93% of orders were closed-loop. These divergent reports may reflect differences in the criteria for what is considered as closed-loop communication. In contrast with the 'standard' or 'classic' form of CLC, Taylor *et al.* (2014) considered the single presence of a checkback as sufficient to close a loop. For instance, an order that was responded to verbally with an "Okay" was considered as a closed-loop exchange. There is clearly a distinction between standard CLC, which requires all three elements to be present, and a simple closed-loop interaction, which contains two elements out of three, with the checkback element loosely interpreted. We argue that it is crucial to clarify which definition is in operation when studying team communication.

CLC usage in out-of-hospital resuscitation settings may vary compared to in-hospital settings. Paramedic teams working in a pre-hospital environment must contend with multiple factors which can impede communication effectiveness. The physical environment is unpredictable, often uncontrolled, and dynamically changing. Physical factors are not always conducive to resuscitation (e.g. very constrained space, cluttered area, physical dangers in the environment, etc.). Moreover, out-of-hospital resuscitation is a highly stressful, time-constrained event. Team configuration is variable, with individual 'experts' arriving at an incident and having to form an 'expert team' on the fly. Previous studies, including Hunziker *et al.* (2010), found that ad-hoc teams are more likely to miscommunicate. Ensuring effective communication in pre-hospital settings will often present a greater challenge than the predictable and optimised conditions of in-hospital surroundings.

The present study investigates the occurrence of CLC in the setting of out-of-hospital cardiac arrest resuscitation. We examine the frequency and forms of CLC found in paramedic dialogues during the crucial five minutes of each resuscitation event, in order to ascertain the extent to which paramedics routinely use CLC, and to identify the factors that influence its usage.

2.0 Method

In this descriptive study, we examined 20 randomly-selected videos of out-of-hospital cardiac arrest resuscitation, applying dialogue annotation as a method. The videos were obtained using body cameras worn as part of the routine audit of team performance by the Resuscitation Rapid Response Unit (3RU) paramedics in Edinburgh between 2013 and 2014. The 3RU is a squad of 12 Scottish Ambulance Service paramedics who have undergone extensive training in technical and non-technical resuscitation skills, which included the use of CLC as a communication strategy. In pre-hospital resuscitation settings, the 3RU joins other attending paramedics (P) to act as team leader.

The routine use of a video audit system using body cameras (VB-200 VideoBadge® from Edesix, a Motorola Solutions company) has been in place for OHCA resuscitations in Edinburgh since 2012. Both video and audio of resuscitation procedures are recorded, securely stored in a bespoke system, reviewed, and subsequently deleted according to a pre-set deletion policy. The videos are used for audit and quality improvement purposes only, to identify priorities for training and service development. They are intended to be reviewed by the pre-defined audit team. Frontline Scottish Ambulance Service staff and staff partnership organisations are familiar with the video audit program. No further individual consent to video recording is required during resuscitation. For this project, the video of each case was redacted to de-identify it, leaving the audio intact. Written confirmation was obtained from the South East Scotland Research Ethics Service that no additional ethical approval was required for this study. Additionally, the study was approved by the Scottish Ambulance Service Research Governance and Innovation Group and the ethics review panel of the School of Philosophy, Psychology, and Language Sciences at the University of Edinburgh.

We decided to focus on the first five minutes of each video starting from the arrival of the 3RU paramedic at the scene, as this is considered crucial to set the tone of the overall procedure (Wik *et al.* 2005; Hunt *et al.* 2008). The 3RU paramedic has gone through intensive technical and non-technical skills training (including communication) for OHCA resuscitation, and as such, will generally adopt the role of team leader in OHCA resuscitation cases. Since OHCA resuscitation is highly time-constrained, 3RU paramedics have been trained to adopt a consistent approach as soon as they reach the scene.

Dialogues were transcribed and then analysed using our dialogue annotation system or coding scheme, which was based on Searle's (1976) Speech Act Theory (SAT). Dialogue theories like SAT have been widely utilised to capture everyday communicative practices, for instance, in the Cross-cultural Speech Act Realization Patterns project by Blum-Kulka and

Olshtain (1984), and to examine medical interaction between doctors and patients (Roter and Larson 2001; Laws *et al*. 2013), but have been less frequently applied, if at all, to analyse medical team communication. We apply the same theoretical background in a high-stakes, real-life context, for which specific communicative strategies have been explicitly recommended.

We transcribed speakers' dialogues in units called *turns*. A turn starts when the speaker starts speaking and ends when she or he stops – whether from the speaker's own volition or because of interruption from another speaker. A single turn can be quite long or simply composed of a single word. Based on the type of speech act, a turn is then segmented into one or more utterances, as shown in (1):

(1)

3RU: So you get on this arm here, and we'll lift him forward

(Video 182, Utterance 41-42, Timestamp 10:01)

In (1), even though the dialogue is uttered in one turn, it is segmented into two: "So you get on this arm here" is viewed as one, and "and we'll lift him forward" as another. The first is a directive for the addressee to move to a specific place and take hold of the patient's arm, whilst the second, even though also a directive, is also a commitment by the speaker to move the patient. Using this method, we obtained a data corpus containing 2,660 utterances in total (min = 74, max = 189, mean = 133 per video). Each video has 3-7 speakers (min = 3; max = 7; mode = 5).

This type of line-by-line dialogue analysis has been widely applied in physician-patient interaction (e.g. Roter and Larson 2001; Laws *et al.* 2013) and shown to be useful in measuring constructs relevant to medical team communication, such as team situation awareness (Parush *et al.* 2011). An abridged list of our coding categories is given below in Table 2:

(insert Table 2)

The segmented dialogues were then analysed for the presence of CLC. Following the classic definition of CLC, we looked for the presence of three components – a call-out, a checkback, and a closing. For this study, we opted to investigate call-outs that contain instructions or directives, like requests, suggestions, and commands, which essentially require some actions to be performed. Utterances tagged with Action-directive were considered as call-outs. We then examined whether these call-outs were responded to and determined the type of response each had. A CLC checkback is tagged when the response is in the form of an Accept, a Repeat-rephrase, and even a Commit, but not an Acknowledge. Instead, Acknowledge is tagged as a CLC closing. Example (2) illustrates a Commit as a checkback and an Acknowledge as a closing, whilst example (3) illustrates a Repeat-rephrase as a checkback and an Acknowledge similarly functioning as a closing:

(2)

P2:	uh can you pass me up a green please	Action-directive	Call-out
3RU:	I'll give you that pal	Commit	Checkback
P2:	Thank you	Acknowledge	Closing

(Video 412, Utterance 149-151, Timestamp 06:41)

(3)

3RU:	Alright so leave him	Action-directive	Call-out

P1:	leave him	Repeat-rephrase	Checkback
3RU:	Alright	Acknowledge	Closing

(Video 290, Utterance 98-100, Timestamp 03:31)

2.1 Challenges

Since the study relies on transcription of audio from real-life incidents, it is limited to what is intelligible. Some verbalisations were not captured by the microphone. To optimise transcription, all transcriptions were reviewed, and where necessary, corrected, by a medical expert (AC) with experience of using the video audit system and who is familiar with the 3RU resuscitation procedure. Where necessary, further reviewers (GC, LM) helped to decipher particularly difficult utterances. A small number of verbalisations remained indecipherable.

3.0 Results

We obtained the following results from the transcriptions.

3.1 The frequency of CLC

Classic CLC is not a communication strategy that appeared frequently in the first five minutes of real-life OHCA resuscitation. Fewer than one example of CLC was found per video in the first five minutes of OHCA resuscitation. Of the 20 videos, only 11 videos contained any instances that satisfied the criteria of a classical CLC, i.e., an occurrence that comprised a call-out, a checkback, and a closing. Overall, 18 occurrences were identified out of a total of 676 directives. This means that only 2.7% of the directives formed CLC. Detailed analysis of the dialogues revealed instances of call-outs that could have been checked back and then closed but were not, especially when they contained specific information like numbers (the type of call-outs typically shown for appropriate CLC usage), as in the following extract:

(4)

3RU: If you've got a cannula, then get a 20ml syringe ready coz that's what I'm going to need next

P2: Yeah

P2: well spotted A

P2: Gotta flush for M

P2: then I'm gonna get him some drugs

(Video 237, Utterance 126-130, Timestamp 09:50)

A classic CLC would require a repetition or a rephrase of the call-out. Instead, P2 responded with an acceptance ("Yeah"), a compliment ("well spotted A"), an assertion ("Gotta flush for M"), and a commit ("then I'm gonna get him some drugs").

3.2 The forms of CLC

What is striking is that although CLCs did occur during OHCA resuscitations, albeit to a very limited extent, real-life CLCs did not look like the textbook examples that are typically provided. The 18 identified instances of CLC revealed that checkbacks in these interactions are normally acceptances of the call-out, similar to the one in example (2), and not specifically a repeat or a rephrase of the original statement. Moreover, instead of clean, uninterrupted dialogues between the speaker and the addressee, we discovered broken dialogues, interjected dialogues, overlapping dialogues, and awkwardly-phrased dialogues; all of which, nonetheless, managed to form closed-loops. These 'deviant' varieties of closed-loop exchanges suggest that the same communicative functions of giving a directive, acknowledging the directive, and responding to it, that are usually characterised in manuals and guidelines can also be achieved through other interactive sequences. Our results suggest that research on CLC may need to consider a wider range of interactive sequences than currently considered to identify the full range of ways in which CLC can be achieved and the extent to which non-standard CLC may achieve the same communicative benefits as proposed for CLC.

More commonly found in these dialogues were sequences that completed the first two parts of the ideal CLC – the call-out and the checkback. If we were to follow Taylor *et al.* (2014) and define CLC as a statement that is verbally acknowledged with any forms of checkbacks (i.e. without requiring a discrete closing of the loop), the number of CLC in our data rises significantly. To differentiate this type of communication from the standard form CLC, we put statements that were merely responded to, without formally closing the loop, into a category that we called closed-ended communication. We identified 113 closed-ended communication instances in our data comprising 16.7% of directive utterances. (5) and (6) are two such examples:

(5)

3RU:	Okay, do a wee rhythm check	Action-directive (call-out)
P1:	Okay	Accept (close)

(Video 411, Utterance 51-52, Timestamp 04:09)

(6)

3RU:	You're in charge of the timing	Action-directive (call-out)
P1:	Yeah	Accept (close)

(Video 414, Utterance 62-63, Timestamp 05:35)

As illustrated, what counts as the closed-ended communication's checkbacks are not always in the form of either repeat or rephrase, but rather one-word acknowledgments. The loops are therefore closed, but without the verbal confirmation of accurate information receipt. Seeing as CLC by definition is required to guarantee, or at the very least, make almost certain that the previous utterance has been understood, we note that the use of one-word acknowledgments to convey acceptance of the directive may not be sufficiently clear as to what action or notion the addressee was accepting or agreeing to, or whether the message was understood as intended. However, we observed no verbal evidence of adverse outcomes resulting from closed-ended communication that used one-word agreement in our data. Thus, on the basis of the current data, it remains an open question whether miscommunication arises due to the use of closed-ended communication.

Possible factors influencing CLCs and closed-ended communication

Collapsing classic CLC and closed-ended communication into a single category, we calculated the frequency of directives that were left open-looped, i.e. with no verbal response. From 676 directives in the 20 videos, 545 were open-looped. Using our coding scheme, which categorises the kinds of subject-matter contained in each utterance, we further examined the subject-matter of each directive to determine whether a particular subject-matter was predisposed to open-looped communication. The frequencies of different subject-matter of utterances and percentages of open-looped exchanges are given in the following Table 3:

(insert Table 3)

It is possible that directives containing the name of the intended addressee, e.g. "Adam, throw away the puck" would invite verbal responses from the addressee rather than general directives like "Someone throw away the puck". Similarly, directives couched in the form of a question, like the request "Can we pull him up?", may show more verbal responses compared to directives in the form of a statement, like the instruction "Pull him up".

To check whether the use of names in directives affected verbal responses, we identified Action-directives that contained specific addressee names. Out of the total 676 directives, only 65 specifically mentioned addressee names. From the 65 name-specific directives, we found that 21 (32.3%) elicited either CLC or closed-ended communication, whilst 44 (67.7%) did not. We then identified Action-directives that were verbalised as questions and established 111 such instances. From this total, 47 (42.3%) resulted in either CLC or closed-ended communication, and 64 (57.7%) were open-looped. These findings indicate that even though specific addressee names and the semantic form of the directives appeared to elicit more CLC or closed-ended communication responses, on their own, they still did not do so in the majority of cases. When addressee name is combined with question-form directives, however, we observed more frequent verbal responses. In our data, this combination occurred only 19 times, but 11 of these instances (58.0%) were closed-ended communication, suggesting that this type of combination may increase the likelihood of a verbal response in the OHCA resuscitation context.

4.0 Discussion

Previous studies have observed that CLC is not frequently applied in medical communication, but less often offered the reason why or attempted to discriminate particular stages/tasks where CLC is not used. The data in our study provide evidence that CLC is rarely used during the first five minutes of pre-hospital OHCA resuscitation, even with explicit training that encouraged the use of the strategy, and more importantly provide some suggestive indications as to why this might be the case. Moreover, we identify specific features of OHCA resuscitations making CLC less likely to be present.

First, standard CLC structure requires that information is conveyed one element at a time by turns, i.e. the speaker verbalises a call-out (one element, one turn), then the addressee responds with a checkback (one element, one turn), and finally the speaker acknowledges the addressee (one element, one turn). This assumption about turn-taking is not always realized in natural dialogues, especially when speakers perceive that they need to do things quickly. Our data show that turns in real-life OHCA dialogues do not alternate neatly between speakers: for instance, in the dialogue below, we can see that P1's response to the earlier instruction by 3RU (both in italics) has been pushed six turns away:

(7)

3RU:	*Just di-disconnect that*	Call-out
3RU:	Just a second	(1)
3RU:	In fact keep going	(2)
3RU:	I'll get his clothes cut off first	(3)
3RU:	sorry guys	(4)
3RU:	Keep goin	(5)
3RU:	we'll get this cut off first	(6)
P1:	*I've just disconnected anyway cos it's uhh*	Checkback
3RU:	right	Closing the loop

(Video 412, Utterance 32-40, Timestamp 03:28)

In this case, the loop (from the first directive in the call-out) is still closed, albeit at a distance. But how far can one get before the call-out becomes too distant to be closed? Such a delayed closure loop, according to Parush *et al.* (2011), makes communication more susceptible to information loss. Our data show that addressees can and do close the loop after a considerable delay (involving both elapsed time and intervening linguistic material), but they do not discriminate the maximum interval before the closure becomes unnecessary or ineffective, i.e. when the checkback is too distant from the call-out to be useful, or when the checkback is preceded by other linguistic material unrelated to the original call-out. Further studies investigating this question may require considering both the relevant temporal window (in example (7), around eight seconds) and the relevant linguistic window (example (7), six turns involving 24 words and four different types of speech – directive, commit, apology, open option).

The second reason why paramedics may not use CLC relates to the stage of the procedure being carried out or the nature of the task at hand. We posit that during particular stages or tasks, CLC is not required, nor is it appropriate. In the first five minutes of our videos, 3RU paramedics are focused on optimising their patients' physical positioning in the environment to enable resuscitation (e.g. making room to apply a mechanical device to deliver chest compressions). We can see from Table 3 that the most frequently verbalised topics concerned patient movement and equipment, and therefore, many instructions mandated non-verbal or action responses rather than verbal responses. When a paramedic said, "Raise his arms", for instance, the immediate response would be to raise the patient's arms; a verbal response in this case was not necessary as the action itself constituted a checkback (assuming that the action was visible to the speaker). The lack of use of CLC here thus did not entail the possibility of miscommunication. Example below:

(8)

3RU: Okay like that,

3RU: you got her head

3RU: Under the *oxters

3RU: Bring her up a little

3RU: Pop it over the top

*oxters = armpits in Scottish dialect

(Video 237, Utterance 37-40, Timestamp 06:09)

We offer three possible explanations of why CLC is regularly reported in some aviation and military contexts but not customary in an OHCA resuscitation context. First, air traffic communication has no physical shared co-presence, hence communication is purely verbal. OHCA resuscitation, on the other hand, is a face-to-face scenario during which team members can respond to verbal commands with visible actions. As the previous example (8) illustrates, verbal responses can be rendered unnecessary.

It is notable that in the International Civil Aviation Organisation (ICAO) Standard Phraseology reference guide and the Civil Aviation Authority's (2015) Radiotelephony Manual used by the aviation and the military, closed-ended communication via readbacks is used far more frequently than classic CLC. Dialogues between the pilot and the air traffic controller normally consist of two parts: the speaker's utterance and the addressee's readback. It may be that the three-part, classic CLC is most useful in well-practised emergency drills (as opposed to routine scenarios), where extensive training including a set series of communications bolsters CLC usage. It is also possible that recommendations for classic CLC may come from evidence based on very specific contexts (e.g. early military radio talk, flight trouble) and established with a different definition of CLC than the classic three-part definition. Therefore, its use in medical contexts may only be relevant for similar kinds of specific situations.

Second, both the military and aviation sectors employ phrase standardisation. In military radio talk for instance, standardised (and abbreviated) terms like *Roger,* meaning "message received", and *Wilco,* meaning "will comply", ease repetition and loop closure (Peyre 2014). Presently, there is no similar form of standardisation in resuscitation communication. Hence, the dialogues during resuscitation procedure, as we have seen from the data, were 'freer', i.e. conducted with very few (or no) verbal protocols. Some researchers, like Yamada and Halamek (2015), have proposed a list of suggestions of adapted air traffic control phrases for neonatal resuscitation. The use of shorter phrases may make it easier to complete a classic CLC, and a standardised manner of giving directives is likely to be more effective than non-standardised ones. Nevertheless, the unnaturalness of this type of speech to paramedics may deter implementation, especially during tasks that do not require verbal responses, like moving the patient (as in example 8) or cutting the patient's clothes. We need to consider the trade-off between possible greater communicative effectiveness and the training required for paramedics to be fluent in using this kind of communication.

Finally, the use of CLC in medical communication is encouraged rather than obligatory. Our findings thus reflected voluntary CLC usage. Unlike aviation and military personnel, paramedics are not specifically trained and drilled to use CLC. Classical CLC requires time for the elaboration of long-form turn-taking. During OHCA resuscitation events, reliability of information transfer is equally important, but speed and efficiency of communication are also at a premium. It is less clear that classical CLC is feasible in a high pressure, acutely time-constrained setting such as this. We recognise that a classic CLC does make almost certain that the accurate message is conveyed, and that it may be best practice in other domains, but for the current OHCA resuscitation context, the trade-off appears too unbalanced.

In addition, OHCA resuscitations often involve non-experts, like bystanders, and other non-3RU paramedics who may have little experience regarding pre-hospital cardiac arrest. Consequently, classic CLC may not be the best match as a default strategy in the OHCA context, although we consider below whether it might be relevant for some specific actions during the procedure.

5.0 Limitations

Our findings on possible factors affecting the use of CLC and/or closed-ended communication focus on general distributional patterns in a relatively small sample. Even on the basis of this sample, it is clear that full CLC was seldom applied, regardless of opportunities to do so. Our findings also focused on the first five minutes of resuscitation. Whilst this is a vital stage that has been established as a factor that determines the rest of the OHCA resuscitation quality, we acknowledge that with a larger set of data, which might include a longer window of analysis, a clearer pattern (or indeed, a different one) could manifest.

6.0 Conclusion

CLC is widely believed to be an effective strategy in ensuring information accuracy, and it has been frequently advocated as one of the means to minimise medical miscommunication. Despite this, it is infrequently used, even after priming with videos emphasising the strategy (Härgestam *et al.* 2013). Drawing on Searle's SAT as the basis for our coding scheme, we investigated real-life OHCA dialogues and discovered similar findings. Paramedics, even those who have been trained to use CLC, spontaneously used very low rates of CLC during the critical first five minutes after their arrival on scene, particularly in its classic form. Instead, we find evidence for higher rates of use of a looser form of CLC, i.e. closed-ended communication.

The use of this form potentially puts the accuracy of the conveyed information at risk; however, it seems better adapted to resuscitation dialogues than classic CLC, with respect to the immediacy of the task at hand, physical distance of the speaker and the hearer, the cost to time, and the current nature of OHCA resuscitation dialogues. We argue that for directives pertaining to visible, immediate actions like moving a patient, where the visual modality can provide evidence of accurate communication, classic CLC may be unnecessary. The evidence suggests that the presence of visual feedback may be able to function as a replacement of verbal repetition and by doing so, the current task can proceed effectively without having each directive verbally repeated and then acknowledged first. In addition to these, the present non-standardised OHCA dialogues also make it less clear if classic CLC is feasible in this context.

We note that there may be some specific actions for which classic CLC might be useful in OHCA resuscitation. El-Shafy *et al*. (2018) found that intravenous line placement benefitted from the use of CLC in a neonatal resuscitation context. It is also possible that in the OHCA setting, the use of CLC may facilitate the time of completion for this task as well as for other tasks that require clear, verbal confirmation, like administering medication. But as observed above, El-Shafy *et al*.'s (2018) study is the only intervention study lending evidence to successful use of classic CLC during the resuscitation procedure. Its absence in the literature, and in real-life OHCA dialogues, may be indicative of CLC as a less-than-optimal strategy for OHCA resuscitation contexts. Further work that probes into team communication from a different angle, for instance Roberts and Sarangi's (2005) theme-oriented approach, which allows analysis of meaning negotiation between team members, could elucidate better strategies to improve communication in a more context-appropriate way.

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TABLE 1

Types of communication loop

Type	Description
Open-loop communication	Instructions not verbally responded to/acknowledged by the hearer.
Delayed-closure of loop	Instructions verbally responded to/acknowledged by the hearer, but not immediately (i.e. delayed).
Non-directed loop	Instructions that are issued generally without clear addressees.
Open-ended communication	Instructions verbally responded to/acknowledged by the hearer. The hearer response is not acknowledged by the speaker.
Closed-loop communication (classic/standard)	Instructions verbally responded to/acknowledged by the hearer. The hearer's response is further verbally acknowledged by the speaker.

TABLE 2

Abbreviated list of coding categories

Forward Communicative Functions The speech categories associated with classic speech act theory		
Assert	Utterances with explicit claims, e.g. facts, beliefs, hypotheses, judgements, conclusions, explanations, etc.	"There was no sign of life when we got to him" "I got one there aye" "Toxins, no sign of drugs, OD or anything at all"
Action-directive	Utterances that directly influence the hearer's future non-communicative actions. This function creates an obligation that the hearer does the action unless the hearer indicates otherwise (unable to comply or refuse to). Comes in several variants (request, suggestion, instruction, command, hint, etc.).	"Secure it for me please" "Continue ventilations" "And bring the AutoPulse* in"
Info-request	Utterances that introduce an obligation to provide information, by any means of communication, but usually verbal (i.e. questions, queries).	"What's happened?" "Any pulse?"
Commit	The defining property for this function is that they potentially commit the speaker (in varying degrees of strength) to some future course of action, without requiring hearer's agreement.	"I'll insert this" "I'll be, I'll swap up next"
Alerter	Phrase/term used to address a person or persons specifically, typically name, but could also be generic terms like Guys, People. Usually appears at the beginning of an utterance.	"Uh, M?" "Okay, guys?"
Backward Communicative Functions		

How current utterance relates to previous dialogue(s)		
Accept	Accepts the proposal wholly.	S: “Let me know and I’ll pre-charge” R: “Okay”
Reject	Disagrees with the proposal.	S: “You want a cricoid?” R: “No no only the tube for now”
Acknowledge	Short utterances that signal that the previous utterance is understood, without necessarily signaling acceptance. Backchannels are a typical example.	S: “She’s been unwell…” R: “Uhuh” S: “…and GP’s been in to see her”
Signal-non-understanding	Utterances explicitly indicating a problem in understanding the previous utterance.	“Hmm?” “What’s that?”

*AutoPulse is a device for delivering mechanical chest compressions

TABLE 3

Open-looped communication based on subject-matter in the first five minutes of OHCA resuscitation

Subject-matter	Total no. of utterances	Open-looped f	Open-looped %
Status (patient’s medical status like blood sugar level)	3	3	100
Other (e.g. regarding bystanders, or indecipherable/inaudible)	54	47	87.0
Medication (e.g. amiodarone, adrenaline)	23	20	87.0
Clothes (specific mention of clothes, usually cutting clothes off)	20	17	85.0
Shock (specific utterances about shock, shocking)	18	14	77.8
Move patient (movement of patient)	147	114	77.6
Time (explicit mention of time)	16	12	75.0
Airway (procedure, action about airway access – NPA, OPA, iGEL, ETT)*	27	20	74.1
Compression (related to chest compression)	83	61	73.5
Move (movement of people, material)	63	46	73.0
Vicinity (specific mention of vicinity)	18	13	72.2
Rhythm (e.g. asystole, PEA**)	28	20	71.4
Ventilation (acts, procedures, mentions regarding ventilation)	15	10	66.7
Equipment (equipment mentioned)	161	106	65.8

*NPA: Nasopharyngeal airway; OPA: Oropharyngeal airway; iGEL: Supraglottic airway suction tube; ETT: Endotracheal tube

**PEA: Pulseless Electrical Activity