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Non-technical skills in cardio-respiratory arrest: a literature review

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ABSTRACT

Introduction: Non-Technical Skills (NTS) are the cognitive, social and personal skills complementary to technical skills that contribute to safe and efficient performance. The aim of this review is to investigate the relationship between NTS and Technical Skills (TS) and to evaluate how the former can positively influence the latter in Basic Life Support (BLS) and Advanced Life Support (ALS) life function support situations.

Materials and methods: the search was carried out in the following databases: PubMed in Medline, Cinahl Complete, Google Scholar. Following examination of the abstracts of 213 articles and the inclusion of criteria such as adult patients in non-trauma-related cardiac arrest in both intra- and extra-hospital settings, including simulated-based, 11 scientific articles were selected.

Results and discussion: NTS were correlated with TS in real ALS situations (slope 0.48, 95% CI 0.34-0.61, $p<0.001$) and in simulated CPR scenarios ($U=43.5$, $p=0.014$); ($r=0.45$, $p<0.05$). NTS showed a positive association with TS in the presence of external stressors ($r=0.67$, 95% CI 0.40-0.83, $p<0.001$). A team approach to CPR would appear to increase the odds of survival to discharge (OR 1.68, 95% CI 1.48-1.91) and neurological recovery (OR 1.52, 95% CI 1.31-1.77).

Conclusions: NTSs appear to have a positive impact on practitioners' technical skills and patient outcomes, although further research is needed to fully understand their true association.

Key words: non-technical skills, cardiopulmonary resuscitation, heart arrest, crisis resource management, advanced cardiac life support.

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Introduction

In Europe, the annual incidence of out-of-hospital cardiac arrest is between 67 and 170 cases per 100,000 inhabitants and the survival rate to hospital discharge is on average 8%. However, the actual incidence is highly variable between different countries and probably underestimated.[1] The annual incidence of in-hospital cardiac arrest, however, is estimated between 1.5 and 2.8 cases per 1000 hospitalizations, with a 30-day or discharge survival rate that varies between 15% and 34%. However, the data reported above have multiple limitations: they derive from single-center studies and are not very generalizable.[1]

Non-Technical Skills (NTS) are defined as the "cognitive, social and personal skills complementary to technical skills and necessary for efficient and safe operations"[2] and are assuming growing importance especially in sectors characterized by significant risks and complex technologies.[3] The need for a greater understanding of the human dimension of operations from a workplace safety perspective arises in fact from civil aviation, a field in which it has long been known that if personnel had demonstrated better non-technical skills, many accidents would not have taken place.[3]

Although there are various definitions of NTS in the literature and their importance in basic and advanced support of vital functions is now established, the literature has yet to reach a consensus on the definition of the construct of NTS.4

The review by Evans *et al.*, 2021, proposes a common taxonomy to define non-technical skills within resuscitation teams operating in various settings (pre-hospital, emergency departments, trauma centers) which are often composed of personnel specialized in different fields (emergency medicine, anesthesia and resuscitation, surgery) and with different professional profiles (doctors, nurses, etc.; Table 1).[4]

Among the main NTS, the literature identifies communication, teamwork, leadership, situational awareness, decision-making and stress management.[2,3,5,6,7]

Communication is fundamental to patient safety and to providing high-quality healthcare: communication failures are in fact known to be a major cause of inadvertent harm to patients.[5] In teams made up of healthcare professionals with different knowledge, skills and responsibilities, the primary purpose of communication is to facilitate a shared mental model of a situation among members, therefore to ensure that context, objectives, methods, roles and actions are known and understood by everyone.[5,8] Some studies highlight how to ensure correct transmission and understanding of critical information, the so-called "closed-loop communication" should be used, *i.e.* closed-circuit communication: the sender sends the message, the recipient confirms the arrival of the message and repeats to the content to confirm the understanding (feedback); finally, the sender verifies the accuracy of the message.[5,9,10] On the other hand, it would seem that standardized communication through unique phrases agreed in the team briefing or during training courses has the potential to reduce the time of starting chest compressions and delivering the first shock via defibrillator, proving to be more effective than closed-circuit communication.[8]

As regards teamwork, it is argued that the failure of dynamics within the group causes accidents;[3] teams are in fact becoming increasingly important in organizations, given that people with different skills are often involved in the same activities.[3] A team approach allows a better distribution of physical and cognitive fatigue among members, avoiding overload:[5] interpersonal communication, effective exchange of information, coordination, mutual support and conflict resolution are therefore important.[2]

Leadership plays a key role within the team, a complex concept to explore. A leader is "someone chosen (by the team itself or by others) to exercise authority and influence over the team" and it is important that he or she creates an environment in which the open exchange of information between various professionals is facilitated.[5] Furthermore, he must be able to manage the cognitive and work load of the entire team.[3]

Situational awareness is also present among the main Non-Technical Skills (Table 1), which is essentially "the perception of elements in the environment, the understanding of their meaning [...] and the projection of their status into the near future neighbor";[5] this occurs through continuous monitoring of the environment and events, paying attention to what happens and intercepting possible changes, to process and give meaning to the information received through the person's memory and mental models.[2,11]

Situational awareness therefore allows and facilitates decision-

Tabella 1. Taxonomy of NTS according to Evans JC *et al.*, 2021.

Taxonomy NTS	
Leadership	Ability to create the team, ability to direct and coordinate activities, facilitate team communication, develop and maintain situational awareness
Comunication	Verbal and non-verbal exchange of information within the team and with the environment. Related to situational awareness, mutual monitoring of performance, delegation and assignment of tasks
Teamwork	Teamwork of different professionals to achieve a common goal
Briefing/pianification	Team action planning and role assignment before intervention
Resource management	Adequate allocation of resources (team members and equipment) and their evaluation ability
Stress management	Ability to identify and manage adverse effects associated with team stress and fatigue
Debriefing	Reflective process on the experience in order to identify the strengths and weaknesses of the team
Decision making	A dynamic team process to interpret collected data, plan care, and identify actions to take
Situational awareness	Process of observation and interpretation of events, in the reference setting
Mental readiness	Team psychological skills during performance
Ability to adapt	The ability of a team to anticipate and modify its structure and behaviors in response to dynamic changes in the patient's clinical presentation and environment.
Shared-mental model	Understanding the goals, structures and roles of members within the team.

making, i.e. the process implemented to make a judgment or choose one option rather than another in order to resolve a given situation.[3] The decision-making process can be influenced by stress, defined by the WHO as a "state of worry or mental tension caused by a difficult situation [...], a natural human response that pushes us to face challenges and threats in our lives ",[12] which in turn can reduce cognitive performance (such as reaction time or attention) leading to negative results in terms of patient safety: the management of the so-called "acute stress" is therefore important in an emergency context, that is the stress that professionals experience when they find themselves in situations characterized by high cognitive load and of work.[2]

The European Resuscitation Council Guidelines underline the importance of training in Non-Technical Skills in basic and advanced support courses for vital functions.[13] In a study that aimed to investigate the relational dynamics within the team, evaluating the perception that Italian nurses have of non-technical skills, a questionnaire was administered to 195 nurses belonging to multiple services (118, Cardiology, Emergency Room, Intensive Care Unit, UTIC). To the question "What was done correctly", 64.2% highlighted technical performance, while to the question "What could be done correctly" 40.8% indicated lack of communication, ineffective role allocation, insufficient leadership and reduced adherence to guidelines.[14] Furthermore, 37.5% thinks that through a detailed training programme, communication and dynamics within the team can be improved, a percentage that rises to 79% with regard to additional leadership training.[14] An effective method for integrating technical and non-technical skills into basic and advanced life support training is simulation.[15]

It is defined as "a technique or method that allows you to create experiences that mimic the processes and conditions of the real world to achieve one or more training objectives", which "allows you to build a wealth of experiences from which to draw without causing damage, operating in safety without risks for the patient": it is therefore useful for a better management of errors, as it allows you to change your attitude towards them, looking at them as stimuli for improvement stimuli and trying to understand their nature and cause.[16]

Simulation, essentially, allows healthcare professionals to be trained in technical skills but also to understand the effects of human factors on performance and to improve specific NTS.[13]

Materials and Methods

This review of the scientific literature asks the following question: "In the treatment of patients requiring basic or advanced support of vital functions, do NTS influence the technical performance of healthcare professionals and patient outcomes in those cases when the latter depend on performance?".

The review was carried out with searching activities in the scientific bibliographic databases of PubMed, Medline, Cinahl Complete, Google Scholar. All the articles published in the last 10 years concerning adult patients (> 18 years) in cardiac arrest who required basic (BLS-Basic Life Support) or advanced (ALS-Advanced Life Support) of vital functions were included in the review, in both an intra-hospital and extra-hospital context. The reason of the choice of the two contexts is related to a paucity of studies regarding patients in out-of-hospital cardiac arrest. Simulated-based studies were also considered. However, articles concerning minor patients and all trauma-related conditions were excluded.

The keywords (Keywords in MeSH) and the searching process in the consulted databases are illustrated in the supplementary materials. The measured outcomes were: improvement in the healthcare professionals' technical performance and patient outcomes (Return Of Spontaneous Circulation, ROSC, survival to discharge, neurological recovery).

Among the identified studies, only 11 answered the search question. The identification, screening and inclusion process is represented in the Prisma Flow-chart.

Results

Peltonen *et al.* conducted a prospective observational study, videorecording real in-hospital ALS situations. NTS and Technical Skills (TS) have been divided into subcategories and scores have been assigned to each one thanks to a tool validated in the literature. The statistical analysis of the results shows that the total NTS score and the total TS score are associated with each other, with a slope of 0.48 (95% CI 0.34-0.61, $p<0.001$): when the total NTS score increases by 1, the total number of TS increases consequently by 0.48. Furthermore, it is highlighted that all the NTS subcategories were associated with the total TS score (slopes 0.29-0.39, $p<0.001$) and almost all the TS subcategories with the total NTS score (slopes 0.37-0.56, $p<0.01$).[17]

Kim *et al.* disclosed a prospective observational study using "in situ" simulations of in-hospital cardiac arrest. The first 5 minutes of each simulation were taken into consideration and the teams were divided into two groups ("high scores" and "low scores") based on the medians of the scores recorded in non-technical skills. The CPR technical performance scores of the group with higher scores and the group with lower scores showed a statistically significant difference ($U=43.5$, $p=0.014$): this means that higher the score in non-technical skills is, higher it is the level in technical skills.[9]

Riem *et al.* performed a retrospective analysis of simulated cardiac arrest situations to investigate the relationship between NTS and TS. Technical performance was measured by a checklist, while Non-Technical Skills were assigned a score using the ANTS (Anaesthetists' Non-Technical Skills): the correlation between NTS and TS was found to be positive ($r=0.45$, $p<0.05$), as well as that between the different subcategories of the two variables ($r=0.31$-0.45).[18]

Krage *et al.* conducted a randomized controlled cross-over study in which a resuscitation team was called to intervene in two different scenarios (in one of the two there were external stressors, such as a family member interrupting the team leader and a constant noise of radio, not in the other). The analysis revealed a positive correlation between the team leader's non-technical skills and general technical performance in the scenario characterized by external stressors ($r=0.67$, 95% CI 0.40-0.83, $p<0.001$), while no evidence of a relationship emerged in the scenario without sources of stress ($r=0.15$, 95% CI 0.22-0.49, $p=0.42$).[19]

Kim *et al.* carried out a systematic review with meta-analysis to determine the effects of team cardiopulmonary resuscitation ("team-CPR") on the outcomes of patients with out-of-hospital cardiac arrest. It turns out that patients who received team CPR, compared to those who did not, had a greater chance of survival to discharge (with OR 1.68, 95% CI 1.48-1.91) and better neurological recovery (with OR 1.52 , 95% CI 1.31-1.77). As far as the third outcome taken into consideration, the ROSC, no significant difference was detected (OR 1.59, 95% CI 0.76-3.33).[20]

Dewolf *et al*. performed a systematic review according to the PRISMA guidelines and the risk of bias was assessed using a tool validated in literature, the Medical Education Research Study Quality Instrument (MERSQI). The most relevant studies taken

into consideration for this review are the 25 concerning non-technical skills (leadership, communication, teamwork, stress management): in multiple studies, the training of non-technical skills has been proved to be effective for the improvement of all both technical and non-technical skills.[21]

Stærk *et al.* published a prospective observational study using unannounced "in situ" simulations, at the end of which a semi-structured debriefing was performed, then analyzed using a qualitative approach, which highlighted barriers and facilitators for better technical success of the treatment. Among the facilitators we include: clear and comprehensible communication, closed-circuit communication, efficient assignment of roles (facilitated in turn by explicit verbalization), leadership identified in the first moments of treatment, effective distribution of actions to be undertaken, brief overview of the situation (summary), statement of the actions already performed. The perceived barriers instead included: lack of communication, absence of effective and timely leadership (which consequently leads to confusion and delay in the assignment of roles and tasks).[22]

Cormack *et al.* presented a scoping review to establish a literature basis to consult and to identify the most relevant Non-Technical Skills for the teams managing out-of-hospital cardiac arrest. All articles (with the exception of one) deal with three non-technical skills which were therefore identified as the most common and consequently the most important: communication, leadership and teamwork. Lack of communication has been highlighted as a barrier (less clarity of roles, unnecessary interruptions, delays in starting to carry out actions), while effective leadership translates into better dynamics within the team (especially when the team leader does not actively participate in the treatment), which consequently lead to better technical performance (reduction of errors and interruptions, clearer communication, reduction of individuals' work overload).[10]

Lauridsen *et al.* conducted a pilot study to investigate the effectiveness of standardized communication (agreed in the team briefing) in reducing chest compression interruptions in a CPR scenario, compared to closed-loop communication. The results demonstrate that the use of the so-called "standardised communication" can reduce interruptions during chest compressions, lower frustration levels and reduce intubation and rhythm control times.[8]

Buljac-Samardzic *et al.* carried out a systematic review of 297 studies (the level of evidence was assessed using the GRADE system) to identify interventions useful for to improve team performance. Of these studies, 69 focus on simulation training (most of which were carried out in emergency situations), which appears to be an effective method for to improve some Non-Technical Skills, such as teamwork, communication, development of a shared mental model and efficient distribution of roles and actions, resulting in improved overall team performance.[23]

Truchot *et al.* published a multicenter randomized controlled trial to investigate whether specific interruption reduction training has a positive impact on the quality of ALS. Comparing the intervention group (with specific training) to the control group (without specific training), no particular differences are highlighted between the two, neither with regards to the NTS (assessed through the TEAM score), nor with regards to TS (assessed through the measurement of "no flow time" and the depth and frequency of chest compressions).[24]

Discussion

In literature, NTS, particularly in emergency situations, represent a less explored topic than technical skills (such as chest compressions, rescue ventilations or the delivery of shocks via defibrillator). However, the studies included and analyzed in this review underline how non-technical skills (and the training concerning them) are also important for the success of treatment in situations of basic or advanced support of vital functions.[8-11,17,18,22]

It was highlighted that "the resuscitation teams that showed better NTS also performed better technical performances in advanced life support"[17] and again "the team with a higher level of non-technical skills obtained higher scores in technical performance of cardiopulmonary resuscitation than the team with a lower level".[9] Another study also shows a statistically significant positive correlation between technical and non-technical skills: a better performance in the former translates into a better performance in the latter, and vice versa.[18] Since cardiac arrest is a time-dependent emergency situation, the first minutes of treatment are fundamental: "Seven studies investigated the effect of NTS on general performance. All showed a significant improvement in the timing of the execution of the first phases of treatment and in the management of the team".[21] To reinforce these findings, in the study by Peltonen *et al.* of 2020, all subcategories of non-technical skills are also positively correlated with technical skills.[17] From the review by Cormack *et al.* of 2020, it emerges that "the three NTS most commonly associated with teams specialized in the management of cardiac arrest are leadership, communication and teamwork".[10]

Regarding leadership, in the review by Dewolf *et al.*, 2020, three studies showed a positive association between good leadership and overall technical performance; it follows that a clear and a leadership present since the first moments of the treatment for facilitates team work and consequently the management of the interventions to be implemented, while the absence of a team leader or the doubt about who is designated in this role are perceived a barrier.[21,22,25]

In addition, effective leadership could also lead to an earlier initiation of the early stages of treatment[21] and a reduction in work overload.[10] In four of the articles examined by the review by Cormack *et al.*, 2020, it also appears that a "hands-off" team leader, *i.e.* one who does not directly perform any technical performance (such as chest compressions), leads to a minimization of projections and a general improvement in the technical quality of resuscitation (reduction in times to start chest compressions, greater adherence to guidelines) with the possibility that this could contribute to an improvement in ROSC.[10]

In the study by Kim *et al.* in 2015, however, no significant differences were found in the following technical performances: maintenance of the compression/ventilation ratio 30:2, frequency and depth of compressions, application of the pads, time elapsed before the delivery of the first shock, ...; based one's your level of leadership skill.[9]

Another NTS among the most common ones is communication: improving it within the team could lower stress levels, improving information management and dynamics within the group, favouring the subdivision of actions and the process of decision making.[17] According to Kim *et al.*, 2015, "it is important to highlight that differences in communication levels positively influenced the technical performances of cardiopulmonary resuscitation".[9] In numerous studies, clear and easily audible communication, above all of a "closed circuit" type, has been highlighted as a facilitator of treatment; vice versa, a lack of communication or ineffective communication was found to be a barrier.[9-11,22,25] On the other hand, the study by Dewolf *et al.*, does not show statistically significant results relating to 'wise announcement.[21]

Regarding teamwork, the articles reviewed by Dewolf *et al.*, 2020, show that following specific training on this topic, improve-

ments are recognised in the general performance of the team, in the management and sharing of information, and in load distribution of work: all factors that can contribute to a successful treatment.[11,21] The UK Resuscitation Council and the American Heart Association in fact emphasize a "team-based" approach to cardiopulmonary resuscitation[10,26] which places a focus on an effective assignment of roles and responsibilities and on a balanced distribution of the workload.[20] As highlighted by the meta-analysis by Kim *et al.*, this approach is associated with the outcomes of patients who are victims of cardiac arrest: there is a greater probability of survival to discharge and better neurological recovery, while no statistically significant result emerges regarding the ROSC.[20,27] Of the examined studies in this review, in addition to that of Cormack *et al.*, this meta-analysis is the only one to observe the effects of NTS on patient outcomes.

Another important aspect to consider in emergency situations is stress, which, combined with cognitive overload, could lead to improper prioritization of tasks and incorrect execution of actions:[22] delays in carrying out key elements in resuscitation have been highlighted, such as the start of chest compressions, the call to the specialized team and the delivery of the first shock in the presence of shockable rhythms, recognized as the most important points in the chain of survival as far as the improvement of the outcome of survival is concerned.[1,13,22,26] Among the barriers perceived during the treatment are: lack of communication, unclear leadership and inability to effectively assign roles and actions: it follows that NTS could take an even greater importance in stressful situations.[19] A "significant relationship between the non-technical performance of the team leader and the technical performance of the whole team" was highlighted: this relationship was observed only in the presence of external stressors (constant radio noise, family members breaking into the scene), while no association emerged in the control group, in the absence of factors contributing to stress.[19] In light of this, it is therefore appropriate to make a consideration: it rarely happens that emergency situations such as cardiac arrest are free of stressful factors.[19]

To reduce the impact of stress and optimize team performance, training on NTS is fundamental: almost all the studies analyzed studies underline their importance. Cardiopulmonary resuscitation education and training programmes should consider non-technical skills as an important element, because they have an impact on the quality of resuscitation:[9] they could reduce technical errors in emergency situations, improving safety and consequently patient outcomes;[17] furthermore, "they would have the potential to improve performance in cardiopulmonary resuscitation especially in stressful situations".[19] In the study by Truchot *et al.*, 2023, a general training programme on NTS appears to have a positive impact on both non-technical and technical skills; on the other hand, specific training on minimizing interruptions and managing distractions does not appear to improve significantly the quality of ALS.[24]

Scientific literature identifies simulation as the best teaching method to train this type of professionals;[21] it is widely used in healthcare and is associated to a better distribution and understanding of roles, reduction of cognitive overload, with consequent minimization of human error.[10]

A systematic review, which took into consideration 69 intrahospital studies mainly concerning the emergency department, highlighted in the majority of the studies an improvement in some NTS (teamwork, communication, shared mental model, clarity of roles and responsibility) following simulation training.[23]

In accordace with analyzed studies, the "Guidelines on the development of simulation in healthcare in Italy" drawn up by the Ministry of Health in 2022 out put into evidence how simulation is fundamental to guarantee proactivelya reduction in clinical risk and optimize error management , increasing the safety and quality of care.[16] The 2021 European Resuscitation Council Guidelines also indicate that NTS should be integrated into ALS training courses alongside technical skills.[13,15]

Limitations of the review

The main limitation of the review consists in the fact that most of the analyzed studies are based on simulation, which could limit the generalizability of the results, as through this method it is difficult to reproduce heterogeneity and realism (both regarding patients and as regards the settings) of the situations. Secondly, some of the examined studies do not have a high methodological accuracy: it follows that the quality of the obtained evidence from them is low. Another limitation is linked to the various assessment tools of NTS and TS: different methods and tools are used, with items that do not always correspond, making difficult a comparison between the various studies..

It is also specified that the direct correlation between NTS and treatment outcomes is difficult to identify, as there are numerous factors that could be related to the outcome but not to the skills, whether technical or non-technical (for example subjective characteristics , presence or absence of venous or intraosseous access, time elapsed from the event to the intervention of healthcare workers, monitoring systems, use of a mechanical massager and other variables).

Conclusions

NTS have the potential to reduce human error and consequently improve patient safety and outcomes.

Some studies support the existence of a statistically significant association between NTS and TS, suggesting of dealing them not as two independent units but as two interconnected units that have mutual influence.

A fundamental role is played by the team leader, whose non-technical skills influence the technical performance of the entire team, especially in the presence of factors that contribute to create a stressful situation (such as noise).

NTS training was found to be effective in reducing delays in carrying out key elements of the chain of survival, such as initiating chest compressions, calling the specialist team or analyzing the heart rhythm; this translates into a higher quality of cardiopulmonary resuscitation which could also influence outcomes. Some of the examined studies, consistently with the 2021 European Resuscitation Council Guidelines, therefore recommend integrating education and training on non-technical skills into basic and advanced support courses for vital functions, using simulation as the main method, widely used in healthcare and fundamental to improve, in addition to TS, also NTS.

Although there is some evidence that a team approach to cardiopulmonary resuscitation, with an emphasis on non-technical skills, can improve patient outcomes (such as neurological recovery and survival to discharge), the direct effects that NTS have on them, are still little explored in literature.

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Online supplementary materials

Tabella 1. Database search table.

Table 2. Summary of selected studies.

PRISMA 2020 flowchart for new systematic reviews that included only database and registry searches. VERIFY THAT YOU HAVE PERMISSION TO USE THE IMAGE.

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Conflict of interest: the authors declare the absence of conflicts of interest.

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