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Observational Study About the Impact of Simulation Training of Non-Technical Skills on Teamwork: Towards a Paradigm Shift in Undergraduate Medical Training

Estudo Observacional Sobre o Impacto do Treino de Competências Não Técnicas no Trabalho de Equipa: Rumo a uma Mudança de Paradigma na Educação Médica

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ABSTRACT

Introduction: Recently, simulation as an educational method has gained increasing importance in Medicine. However, medical education has favored the acquisition of individual knowledge and skills, while overlooking the development of teamwork skills. Since most errors in clinical practice are due to human factors, i.e., non-technical skills, the aim of this study was to assess the impact that training in a simulation environment has on teamwork in an undergraduate setting.

Methods: This study took place in a simulation center, with a study population of 23 participants, fifth year undergraduate students, randomly divided into teams of four elements. Twenty simulated scenarios of teamwork in the initial assessment and resuscitation of critically ill trauma patients were recorded. Video recordings were made at three distinct learning moments (before training, end of the semester, and six months after the last training), and a blinded evaluation was performed by two independent observers, who applied the Trauma Team Performance Observation Tool (TPOT). Additionally, the Team STEPPS Teamwork Attitudes Questionnaire (T-TAQ) was applied to the study population before and after the training to assess any change in individual attitudes towards non-technical skills. A 5% (or 0.05) significance level was considered for statistical analysis.

Results: With a moderate level of inter-observer agreement (Kappa = 0.52, p = 0.002), there was a statistically significant improvement in the team's overall approach, evidenced by the TPOT scores (median of 4.23, 4.35 and 4.50, in the three time-points assessed, respectively, p = 0.003). In the T-TAQ, there was an improvement in non-technical skills, that was statistically significant for "Mutual Support" (median from 2.50 to 3.00, p = 0.010).

Conclusion: In this study, incorporating non-technical skills education and training in undergraduate medical education was associated with sustained improvement in team performance in the approach to the simulated trauma patient. Consideration should be given to introducing non-technical skills training and teamwork in the emergency setting during undergraduate training.

Keywords: Education, Medical, Undergraduate; Emergency Medicine/education; Simulation Training; Students, Medical

RESUMO

Introdução: Recentemente, a simulação como método educacional ganhou uma importância crescente na Medicina. No entanto, a educação médica tem favorecido a aquisição de conhecimentos e competências individuais, ao mesmo tempo que ignora o desenvolvimento de competências de trabalho em equipa. Uma vez que a maioria dos erros na prática clínica se deve a fatores humanos, ou seja, a competências não técnicas, o objetivo deste estudo foi avaliar o impacto que a formação num ambiente de simulação tem no trabalho de equipa num ambiente de licenciatura.

Métodos: Este estudo teve lugar num centro de simulação com uma população de 23 participantes, alunos pré-graduados do quinto ano de Medicina, divididos aleatoriamente em equipas de quatro elementos. Foram simulados um total de 20 cenários de trabalho em equipa na avaliação inicial e de ressuscitação de doentes com traumatismo crítico. Três momentos de aprendizagem distintos (antes do treino, final do semestre, e seis meses após o último treino) foram gravados em vídeo, seguindo-se uma avaliação duplamente cega por dois observadores independentes, que aplicaram a ferramenta de observação de desempenho de equipas de trauma TPOT. Além disso, foi aplicado o questionário de atitudes de trabalho em equipa STEPPS (T-TAQ) à população do estudo antes e depois da formação, a fim de avaliar qualquer mudança nas atitudes individuais em relação às competências não técnicas. Considerou-se um nível de significância a 5% (ou 0.05) para a análise estatística.

Resultados: Houve um nível moderado de acordo entre observadores (Kappa = 0,52, p = 0,002). Obteve-se uma melhoria estatisticamente significativa na abordagem global da equipa, evidenciada pelas pontuações do TPOT (mediana de 4,23, 4,35 e 4,50, nos três momentos de avaliação respetivamente, p = 0,003). No T-TAQ, houve uma melhoria estatisticamente significativa num grupo de competências não técnicas, "Apoio Mútuo" (mediana de 2,50 para 3,00, p = 0,010), que não foi observado nos restantes grupos de competências não técnicas.

Conclusão: Neste estudo, a incorporação da educação e formação não técnica no ensino médico pré-graduado foi associada a uma melhoria sustentada do desempenho da equipa na abordagem ao paciente do trauma simulado. Deve ser considerada a introdução, no ensino pré-graduado, da formação de competências não-técnicas e do trabalho em equipa no contexto de emergência.

Palavras-chave: Educação de Graduação em Medicina; Estudantes de Medicina; Medicina de Emergência/educação; Treino por Simulação

INTRODUCTION

The approach to polytrauma patients is a clinical challenge. Trauma patients often present in extreme situations, under intense time pressure and great uncertainty about the patient's condition and injuries. In addition, team members will come from various healthcare professional groups and specialties, with different levels of training and who often do not work, or train, together on a day-to-day basis. The success of this team is based on the interdependence of the

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members, each with their role in treating the patient.

All of these constraints can culminate in what is referred to as a "perfect storm of errors and poor outcomes".[1] If we analyze in detail the causes of poor outcomes, we will find that most adverse events (up to 70%) in Medicine are due to human factor errors, that is, failures related to non-technical skills (NTS).[2,3] As expected, adverse events are more likely to happen at times of increased pressure and time-sensitive emergencies, such as in the trauma setting.

Clarke *et al* argue that errors occurring during polytrauma care can occur in up to 100% of all trauma resuscitations.[4] Digressing on the nature of these errors, Hicks concluded that they ranged from difficulties in decision making, obtaining information, loss of situational awareness, and, above all, poor communication and leadership.[5]

Non-technical skills are defined as social, cognitive, and individual skills that interfere with technical skills and the execution of tasks and procedures.[6] Multiple studies have shown that non-technical skills training can improve patient care, patient safety, operating room efficiency, and patient outcomes.[7–9]

Team training in postgraduate education is being developed in most countries, using simulation as an adjunctive learning method due to all its advantages. Undergraduate medical education curricula have emphasized the acquisition of individual knowledge and skills, often in a competitive spirit. The reality of clinical practice, however, is not like this, and the patient benefits when physicians work collaboratively.[10] Still, the reality of undergraduate medical education has failed to promote teamwork skills.[11] In fact, in a recent worldwide survey on trauma team training by our group, we found that only 24% of trauma doctors had training in nontechnical skills at the undergraduate level.[12] The impact of providing such training to medical students using simulation, particularly in the trauma and emergency context, is still largely unknown.

Therefore, the aim of this study was to assess if medical students could acquire and retain teamwork skills in managing simulated trauma patients. Specifically, we aimed to study if there were statistically significant differences in the assessments made before and after the training in non-technical skills and whether those skills were embedded at six months after the last training session.

METHODS

This observational study is based on the elective "Trauma, Emergency and Catastrophe" at the Faculty of Medicine of the University of Coimbra (FMUC) in its inaugural academic year 2020/2021.

The study population consisted of 23 fifth-year medical students (11 from the first semester, and 12 from the second), 11 female, 12 male, with an average age of 22 years, who had no previous training in simulation environments or trauma situations. The study was approved by the institutional Ethical Committee (approval no. CE-095/2021) and all participants gave their informed consent in writing.

During the elective, participants shared common lectures and case discussions, presented by faculty with experience both in the clinical management of trauma patients and teaching experience in postgraduate simulation courses, namely Advanced Trauma Life Support (ATLS™), European Trauma Course (ETC™), and Definitive Surgical and Anesthetic Trauma Care Courses (DSTC™ and DATC™).

The 23 candidates were randomly divided into teams of four. In each team, one candidate was the Team Leader (TL), one the "Airway" doctor (A), one the "Breathing" doctor (B), and one the "Circulation" doctor (C). The scenarios were prepared by the faculty and consisted of a simulated trauma patient with one life-threatening injury. After a prehospital report in a standardized approach, using the ATMIST handover (Age, Time, Mechanism of injury, Injuries, Signs, Treatment), the TL would brief the team, allocate roles, and mobilize resources. The simulated patient (low-fidelity mannequin) would then be brought into the simulated emergency room and the horizontal assessment and resuscitation would start. Communication, decision-making, and teamwork would be required by all team members, with the TL also displaying leadership skills. Progression of changes in the patient's physiology and vital signs were manipulated by the faculty in the SimMon software as the scenario evolved. The scenario would end when the life-threatening condition was managed and there was a decision for patient transfer, either for imaging or for damage control surgery. After each simulation, there was a structured debriefing, facilitated by the most experienced instructor.[13] All team scenarios were originally created by the last author based on the European Trauma Course model.

The first scenario was performed after lectures on trauma management, non-technical skills and team training, several hands-on skills sessions on technical skills, and an initial assessment and management demonstration of the team approach to a trauma patient led by an instructor.

Recordings of clinical case simulations were made at the various learning moments, for a total of 20 videos, allowing for an observational study with descriptive analysis based on the blinded assessment of two independent observers, using the Trauma Team Performance Observation Tool (TPOT) scoring system, which was designed to assess a team's performance.[14] The TPOT scores from the three different learning moments were obtained and compared at three time points: before practical training (BT) – eight videos –; end of semester training (ET) – nine videos – and six months after the last training simulation, which will correspond to the late training (LT) – three videos. In this way,

we aimed to evaluate not only the evolution but also the retention of skills.

The two observers, MJK and FM, surgeon and anesthesiologist, respectively, are two clinicians with vast experience in trauma management and are trained European Trauma Course full instructors. They are unaffiliated with FMUC and did not know the participants. They independently reviewed the videos in random order, without comparing notes with each other, and thus were blinded to the time-point status, BT, ET, or LT of the participants. Based on the consensus of the study authors, questions 14 from Situation Monitoring ("Applies the STEP process when monitoring the situation") and 19 from Mutual Support ("Uses the two-challenge rule, CUS, and DESC script to resolve conflict") were excluded from the TPOT tool (Appendix 1: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/19021/15088), as they did not apply to our predesigned simulated scenario.

Each item was rated using a five-point Likert scale, ranging from 1 (very poor) up to 5 (excellent).

In addition, the Team STEPPS Teamwork Attitudes Questionnaire (T-TAQ) (Appendix 2: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/19021/15089), developed by the US Agency for Healthcare Research and Quality, was applied to assess individual attitudes toward non-technical skills and to understand whether training in these skills resulted in a change in attitudes.[15]

The questionnaire consists of 30 questions, regarding five different non-technical skills, which are rated using a five-point Likert scale ranging from 1 (strongly disagree) up to 5 (strongly agree). The T-TAQ was completed at the beginning of the elective, before any theoretical or practical teaching, and at the end of the semester, allowing the comparison of the results.

The IBM Statistical Package for the Social Sciences (SPSS®) version 27 was used for statistical analysis, with a significance level of 0.05 set. The normality of the distributions was analyzed using the Kolmogorov-Smirnov test.

For each question in the TPOT and T-TAQ scoring systems, we compared the different stages of scores using non-parametric tests. We also compared the overall scores. Two TPOT questions were excluded because they were not applicable, leaving 23 questions on a five-point scale, meaning that the TPOT scores could range from 23 to 115. We assessed agreement between reviewers using Cohen's kappa for each test. The values considered were ≥ 0.61 to indicate a substantial level of agreement, 0.41 - 0.60 to indicate moderate agreement, 0.21 - 0.40 to indicate fair agreement, 0 - 0.20 to indicate slight agreement, and < 0 to indicate no agreement. A 5% (or 0.05) significance level was considered. The comparison of skill evolution and retention was performed by applying Friedman's test, which allowed us to compare the three evaluation moments. The Wilcoxon test was used for analysis and comparison of the results obtained in the T-TAQ questionnaires.

RESULTS

The twenty recorded simulated team resuscitations were assessed with moderate agreement observed in the TPOT Score ratings between independent observers (Kappa = 0.52, $p < 0.001$).

Following analysis and comparison of the videos at the three different assessment time points, the TPOT results were very good. The students, after only the lectures and demonstrations on non-technical skills, without any previous training, obtained high scores in the first training, with a median of 4.25, on a scale of 1 to 5. Moreover, they also improved in a statistically significant way and, more importantly, maintained this improvement over time, increasing and maintaining a median of 4.5 ($p < 0.005$).

Although there were no statistically significant differences in each of the individual non-technical skills between the three investigated time-points, the overall TPOT scores displayed a statistically significant improvement from before practical training to late training, i.e., from the pre-training moment to the six-month retention assessment (Fig. 1, Table 1).

Regarding T-TAQ analysis, all candidates completed the questionnaires (100% response rate).

When studying the total responses for each skill group, we found statistically significant differences in one group of non-technical skills (Mutual Support) between the pre- and post-education questionnaire ($p < 0.05$) (Table 2, Fig. 2).

DISCUSSION

From the first moment, medical students are expected to work and study hard, with the aim of achieving individual excellence. Although this is obviously mandatory in a challenging profession such as Medicine, this individualistic approach underestimates the role of teamwork and mutual collaboration. Furthermore, this system often creates distancing and isolation of the students, who will prioritize the acquisition of individual technical skills and theoretical knowledge, while overlooking the importance of developing NTS, such as communication skills, which are mandatory when these future doctors later integrate clinical teams. For this reason, the training of non-technical skills in undergraduate education and its incorporation into the medical education curriculum is paramount, as it will allow the change from a competitive environment to a collaborative one.[16,17] This is particularly relevant in cases of trauma and emergency – where most medical errors are due to poor communication – and it is important to note that individual

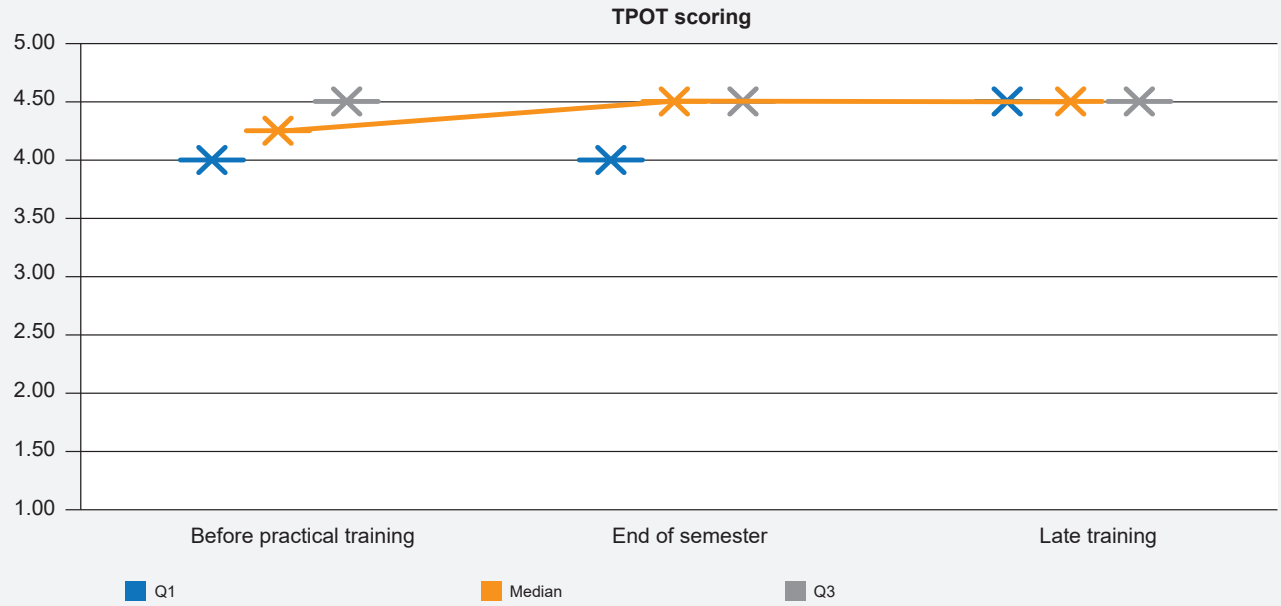

Figure 1 – Evaluation and evolution of team performance through median and interquartile ranges, using the Trauma Team Performance Observation Tool scale, in the three different assessment time points (*p*-value = 0.001)

Table 1 – Evaluation and evolution of team performance through median, interquartile ranges and ranges, using the Trauma Team Performance Observation Tool scale, in the three different assessment time points

	Median	IQR	Range	*p*-value
Before practical training	4.25	(4.0, 4.5)	[3.75; 4.75]	**0.001 (< 0.005)**
End of semester training	4.50	(4.0, 4.5)	[4.00; 5.00]	
Late training	4.50	(4.5, 4.5)	[3.50; 5.00]	

excellence at the technical and scientific level may not be enough for one to be a good team member or team leader.

Currently, team training in postgraduate education is being develop in most developed countries, including Portugal, to improve healthcare and professionals' skills.[18–21] Simulation as an adjunctive learning method has gained prominence in Medicine, as well as in other professions. This method allows skills to be practiced in a protected and deliberate way, allowing for repetition and reflection, providing standardized experiences for all participants, and obviating some inherent flaws in traditional medical education.[22]

During simulation, participants can explore their decision-making, problem-solving, clinical reasoning, and communication skills during simulated scenarios. They are also given the option to discuss their actions with colleagues afterward in a debriefing session, which allows them to reflect upon their performance as well as improve upon it (for example, decisions made leading up to the outcome).[23] Sá-Couto *et al*, in a recent study, showed that debriefing after a simulation scenario improves the acquisition and retention of non-technical skills, in undergraduate students.[13]

Our study assessed whether the medical students' non-technical skills and team performance in simulated trauma scenarios could be developed, trained and retained after some time. Baker *et al* ran a similar study in undergraduate students, from different healthcare programs (physicians, nurses, radiology department and respiratory care), testing their ability to acquire teamwork skills using team-based learning with Team STEPPS. They found encouraging results, with significant improvement in several non-technical skills, including team leadership, situational monitoring and communication, concluding that trauma team education leads to a significant improvement in the scores used.[24] Unlike this study, ours was conducted only on medical students, which is highly relevant, since about 1450 medical students start their training every year in Portugal.[25] Moreover, when we assessed the evolution of the teams' performance in the three different assessment time points , we not only found that the initial NTS were high after a single lecture and demonstration, but also that there was training related improvement and, interestingly, retention of those same skills, six months after the last simulated scenario.

Table 2 – Team STEPPS Teamwork Attitudes Questionnaire groups of non-technical skills results, presented as medians, interquartile ranges and ranges

	Pre-education			Post-education			*p*-value
	Median	IQR	Range	Median	IQR	Range	
Team structure	5	(4.5, 5.0)	[4.0; 5.0]	5	(4.5, 5.0)	[4.0; 5.0]	0.72 (> 0.05)
Leadership	5	(4.0, 5.0)	[3.5; 5.0]	5	(5.0, 5.0)	[4.0; 5.0]	0.36 (> 0.05)
Situation monitoring	5	(4.0, 5.0)	[3.5; 5.0]	5	(5.0, 5.0)	[4.0; 5.0]	0.58 (> 0.05)
Mutual support	**2.5**	**(2.5, 3.0)**	**[1.5; 4.0]**	**3**	**(3.0, 4.0)**	**[2.0; 5.0]**	**0.01 (< 0.05)**
Communication	5	(4.0, 5.0)	[3.5 ;5.0]	4.5	(4.0, 5.0)	[4.0; 5.0]	0.70 (> 0.05)

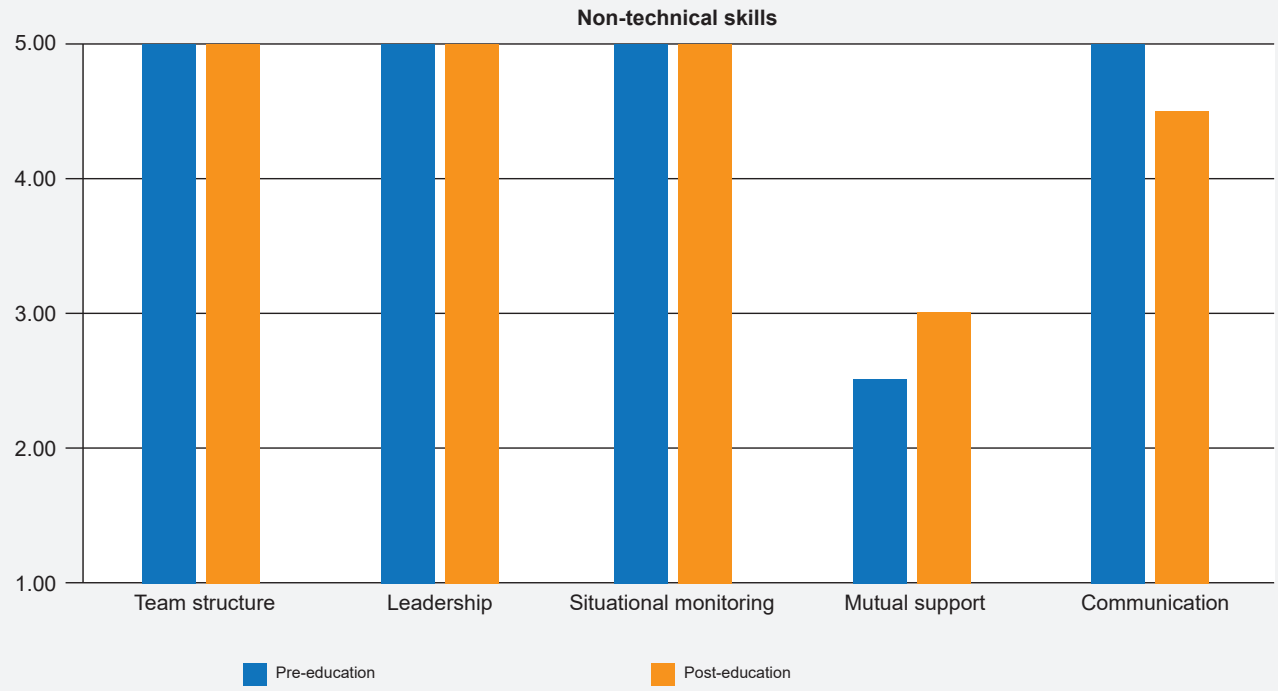

Figure 2 – Self-assessment of the participants NTS (n = 23 participants), before and after the TEC course, using the Team STEPPS Teamwork Attitudes Questionnaire

It can be argued that the students' initial results were very good, probably because the first teamwork assessment was made after exposure to a lecture and a demonstration of non-technical skills. A better demonstration of the acquisition of teamwork skills by the students would be performed by exposing them to the scenarios without this previous preparation. However, in the authors' opinion, this would be unethical since the results would very likely be poor and could induce feelings of frustration and demotivation. Moreover, the use of a control population of students unexposed to these initial lectures and demonstrations, could also be considered unjustifiable.

We were also able to demonstrate that the training of these skills, with the respective debriefing, led to a constant improvement of the TPOT score. Although no differences were found in tested individual NTS that compose the TPOT rating, we postulate that the study was underpowered to demonstrate this. Nonetheless, we find our results encouraging because the median TPOT overall scores displayed a sustained and statistically significant improvement at the six-month time point. Therefore, the simulation-based training enabled the development of these skills in a safe environment, allowed for repetition and consolidated the NTS.[24,26] We must, of course, consider that students may have developed an awareness of the importance of teamwork in trauma management over the course of the semester and continued their studies after the end of the elective. However, this alone may not justify the excellent teamwork that was observed after a six-month break, and some actual effect of the training program was likely responsible for this.

Regarding the results obtained after evaluating the T-TAQ questionnaires at the two different time points, we obtained a statistically significant difference in one skill group, the "Mutual Support". Although the T-TAQ is a questionnaire filled out by the participants, its main purpose is to see if there have been changes in behavior between two different time points. With this result, we concluded that students significantly changed their perception of the non-technical skill of mutual support. In the authors' opinion this means that these undergraduate students probably fully recognized the true importance of teamwork.

This study has several limitations. First, considering that it was the first year of this TEC elective, the study population was small, both in the number of participants in the case of the questionnaires, and in the number of videos in the case of the evaluation of the simulations. Secondly, this study occurred in a simulated setting. Further work is required to validate these findings in a clinical context. However, this does not preclude the proof of concept of promoting teamwork at the undergraduate level. Moreover, obtaining data via filming the simulations may have had an effect on the participants at a psychological level, thus creating a bias. It should also be noted that the TPOT was used as the scale for evaluating team performance, but there are many other scoring systems available. The subjectivity of the results was decreased by the use of two unbiased and blinded observers, both experienced clinicians and educators, who presented moderate agreement. Using video recording enabled the observers to be physically and chronologically removed from scenario, and this has been considered more reliable than live observations to assess trauma scenarios.[27] Finally, the T-TAQ is a self-reported questionnaire, making the results subjective. In addition, it is not known how consistent this self-reported change in behavior is, particularly when the participants start their clinical practice. Furthermore, although the T-TAQ has been used in several studies and its reliability has been verified, it has not been approved specifically for the Portuguese population.

Nonetheless, we believe that the promotion of teamwork through team training and the development of NTS can be easily achieved with simulation-based education in the undergraduate setting. This training may lead to a durable change in behavior, as shown in this study. We highlight that this behavioral change is not acquired just by training these NTS on a one-time basis, but by continuously training and perfecting them, and finally transferring them into clinical practice, to the ultimate benefit of the patients. Also, we believe that trauma and critical patients will benefit the most from the fact that future doctors obtain these skills at the undergraduate level.

CONCLUSION

Non-technical skills training in undergraduate education was associated with improvements in team performance during simulated trauma scenarios. Moreover, there seems to be lasting retention of these skills, which are highly relevant in a culture of safety in modern clinical practice, that is based on multidisciplinary teamwork. Therefore, it is paramount that medical schools recognize its importance, in order to change the students' mindset from a competitive to a collaborative one. This new approach would change the paradigm from a team of excellent individuals to an excellent team, allowing the reduction of human errors and improving performance and team cohesion, and ultimately resulting in better patient outcomes, particularly in trauma and emergency settings.

AUTHOR CONTRIBUTIONS

BM: Design and conception of the study; data collection and treatment; writing and critical review of the manuscript.

LF, HA: Design and conception of the study; data treatment; writing and critical review of the manuscript.

MJK, FM, ES, SB: Data collection.

PROTECTION OF HUMANS AND ANIMALS

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the Helsinki Declaration of the World Medical Association updated in 2013.

DATA CONFIDENTIALITY

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

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