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Simulation-based interprofessional education for the perioperative anaesthetic emergency team: a pre-post study within a multicentre trial

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Abstract

Background: Simulation is the most widely used strategy in interprofessional education (IPE), but it rarely involves the whole team that responds to crises, including support staff. This study explored, by professional category, how interprofessional collaborative competencies and knowledge changed after simulation with the perioperative anaesthetic emergency team. Methods: Pre-post study within a multicentre randomised trial that addressed two questions; the comparison between delivery settings is reported elsewhere, and the data were pooled here. Ninety-eight professionals (28 anaesthetists, 56 nurses and 14 healthcare assistants [HCAs]), in 14 teams of seven, took part in a standardised session on local anaesthetic systemic toxicity, with interprofessional PEARLS co-debriefing. The ICCAS and a knowledge questionnaire were administered before and after the session, the RIPLS before and the SET-M and DASH after. The facilitators' records were analysed post hoc. Results: No HCA had previously taken part in a simulation, compared with 89.3% of anaesthetists and 39.3% of nurses. Readiness for interprofessional learning (RIPLS) was highest in anaesthetists and lowest in HCAs ($p < 0.001$). ICCAS scores did not differ between categories at either time point. They increased in anaesthetists (68.75 ± 8.28 to 79.68 ± 9.88; $p < 0.001$) and nurses (69.43 ± 11.71 to 79.52 ± 12.44; $p < 0.001$), and the change was inconclusive in HCAs (72.79 ± 19.95 to 77.50 ± 19.52; $p = 0.382$), although 9 of the 14 reported on the global item that they collaborated better. Knowledge increased in all categories and DASH scores were similar. On the SET-M, HCAs rated learning and debriefing less favourably. All teams called for help early and redistributed tasks, but closed-loop communication was not always performed. Conclusions: Training the perioperative anaesthetic emergency team in an interprofessional intervention built to the Sim-IPE standard was feasible. The session was associated with higher self-reported collaborative competency in clinical professionals, and observation identified closed-loop communication as the team competency to strengthen. In HCAs, IPE instruments did not capture the change they themselves reported. The study extends simulation-based IPE beyond the doctor-nurse dyad, and future evaluation should include observed performance and follow-up. Trial registration: ClinicalTrials.gov, NCT07346937. Registered 10 December 2025.

Background

Patient safety in the operating theatre depends on the competence of each professional and on how the team communicates, coordinates its actions and responds jointly to complex clinical situations. When a patient deteriorates, tasks are distributed among several team members, and carrying them out depends on information flowing between everyone without loss. Systematic observation in the operating theatre identified failures in about 30% of communication exchanges, some with an immediate effect on the team's work [1]. Understanding how professionals collaborate, and how they can develop the competencies that support this collaboration, is therefore a priority in the education of healthcare teams.

Interprofessional education (IPE) is one response to this need. The World Health Organization defines it as occasions when students or professionals from two or more professions learn with, from and about each other, for a collaborative practice that explicitly includes management and support workers, whether regulated or not [2]. The most recent version of the competencies for collaborative practice adds that each professional should know the scope of practice of every team member and share responsibility for outcomes [3]. The distinction between multiprofessional teams, in which each professional contributes from their own discipline with varying degrees of integration, and interprofessional teams, in which members work interdependently and share decisions, places interprofessional collaboration as a property of the team rather than an individual attribute [4].

Clinical simulation has become the most widely used strategy for IPE in rare and serious events, but the evidence supporting it has known limits. Documented effects are concentrated on reactions and knowledge, almost always measured by self-report [5], and the 2024 global consensus statement on simulation-based practice notes that the

professions continue to train in silos [6]. In a scoping review of 56 interprofessional simulation-based team training programmes, almost half involved only two professions, usually medicine and nursing, only 20.6% framed the training as IPE, and 72.4% were single sessions; the authors concluded that participants learned with each other, but little from and about each other [7]. Bringing several professions together in the same session does not in itself constitute interprofessional education. The best practice standard for simulation-enhanced interprofessional education (Sim-IPE) addresses this gap by requiring a theoretical IPE framework, interprofessional facilitators, objectives aligned with interprofessional competency domains and the evaluation of outcomes that are themselves interprofessional [8].

In the perioperative setting, the pattern is repeated. In a systematic review of 29 simulation studies on crisis management, only one of the 14 studies with group simulation brought together medicine, anaesthesia, nursing and other professions, and none reached Kirkpatrick level 4 [9]. A scoping review of perioperative team training found little use of validated instruments that assess how the team functions as a whole [10]. For two decades, research on teams has held that team competencies are acquired through interaction with the actual members of the team, and that those who work together should train together [11, 12].

Simulation-based IPE has been organised mainly around the doctor-nurse dyad, and the participation of the other members of the clinical team remains little explored [7, 9]. When they are included, the response differs: in the systematic training of the whole team of an intensive care unit, self-efficacy increased in doctors and nurses but not in assistant nurses, who were nevertheless the only group to improve their perception of collaboration and of the safety climate [13]. The Interprofessional Collaborative Competency Attainment Survey (ICCAS), one of the most widely used IPE instruments, measures a perception of collaborative competency close to self-efficacy, which social cognitive theory links to initiative and persistence in demanding situations [14]. It was validated in students of clinical professions [15, 16], and we are not aware of studies that have applied it to support staff working within clinical teams.

Local anaesthetic systemic toxicity (LAST) is a suitable scenario for studying this gap. It is a rare and potentially fatal anaesthetic event whose management requires early recognition, a call for help, rapid administration of lipid emulsion and, in severe cases, advanced life support, tasks that are distributed across different team members [17]. In a multidisciplinary LAST simulation curriculum, technical skills were retained at six months, but early calling for help and communication deteriorated [18].

The aim of this study was to explore, by professional category, how self-reported interprofessional collaborative competencies and knowledge changed after interprofessional simulation with the perioperative anaesthetic emergency team, and to describe how participants perceived the educational experience and how the teams functioned during the scenario. By treating this team as the unit of learning, the study seeks to extend research on simulation-based IPE beyond the doctor-nurse dyad.

Methods

Design: a pre-post study within a multicentre trial

This study is part of a multicentre randomised trial that addressed two questions with the same participants, intervention and instruments. The first, the effect of the physical setting in which simulation is delivered, is the subject of a separate manuscript. The second, how collaborative competencies, knowledge and the perception of the experience changed in each professional category of the perioperative anaesthetic emergency team, is reported here and is not addressed in that manuscript. For the first question, participants were randomly allocated 1:1, stratified by professional category and institution, to two physical settings for delivery of the same intervention. A computer-generated sequence was prepared by an investigator who was not involved in recruitment or data collection, and the allocations remained concealed until the teams were formed. Participants and facilitators could not be blinded to the

setting, and the analysis was not blinded. For the question addressed in this article, the design is pre-post, with no control group. The analysis by professional category was part of the trial's statistical analysis plan; all analyses reported here are exploratory. The extraction of the facilitators' records and the interpretation centred on the whole team were not prespecified. The trial was prospectively registered at ClinicalTrials.gov (NCT07346937, https://clinicaltrials.gov/study/NCT07346937) on 10 December 2025, before enrolment of the first participant. Additional file 1 lists the changes to the protocol, all of which preceded the enrolment of the first participant. Reporting follows the CONSORT 2025 statement [19] and the CONSORT extension for healthcare simulation research [20] (Additional file 2).

Study sites and ethical approval

The study took place in two institutions in the Porto region, Portugal, between March and April 2026, with participants from two services: the Operating Theatre of Unidade Local de Saúde de Matosinhos, Hospital Pedro Hispano (BO-ULSM), and the Post-Anaesthesia Care Unit of Unidade Local de Saúde de São João (UPA-ULSSJ). Sessions were held in these services or at the Simulation Centre of the Faculty of Medicine of the University of Porto (SIMFMUP), according to trial allocation. All participants received the same scenario, simulator, facilitation team, session structure, debriefing script and instruments. Teams who trained at SIMFMUP did so in a room set up beforehand to reproduce the spatial layout and equipment of their own service, so every team worked in the same space whatever the site of the session. This equivalence is what allowed the data to be pooled; the session site is treated as a declared source of heterogeneity and is not analysed.

Favourable opinions were issued by the ethics committees of the Faculty of Medicine of the University of Porto and RISE-Health, Unidade Local de Saúde de Matosinhos and Unidade Local de Saúde de São João, and are identified in the Declarations. The research was conducted in accordance with the Declaration of Helsinki, Good Clinical Practice guidelines and the European Union data protection regulation. As this was educational research with healthcare professionals, patients and the public took no part in any phase of the study.

Participants and composition of the perioperative anaesthetic emergency team

Anaesthetists, perioperative nurses and healthcare assistants (HCAs) who provide the response to an anaesthetic emergency in the participating services were eligible. In Portugal, HCAs have no autonomous clinical duties and act under the direction of doctors and nurses; in the perioperative pathway they are responsible for much of the logistics, including the transport of equipment and emergency supplies. Each professional needed at least three months of practice in the service, availability on the assigned date and written consent. Pregnant professionals and anyone who expected to be unable to complete every stage of the study did not take part.

Participation was voluntary, in a convenience sample. In both institutions, the study was presented first to the heads of the services and then to the teams, in face-to-face sessions, and participants registered through an online form. Teams consisted of two anaesthetists, four nurses and one HCA. This composition reproduces the real response: an initial team of five, reinforced during the crisis by a second anaesthetist and a nurse. In this article, the perioperative anaesthetic emergency team is the team that responds to a critical anaesthetic event in the operating theatre and the post-anaesthesia care unit: anaesthetists, perioperative nurses and HCAs. The scenario took place at the start of anaesthesia, when surgeons are not present in the operating room or in the post-anaesthesia care unit, and they were therefore not included. In total, 98 professionals took part, distributed across 14 teams (Fig. 1). Each team was made up of professionals from a single institution, and each professional took part in one session only. Team members worked

in the same service but did not form a fixed team, as in practice, where the team that responds to an emergency is made up of the professionals on duty at the time.

Clinical scenario and interprofessional objectives

The LAST scenario (Additional file 3) was based on the internal procedures of the participating services and the 2020 checklist of the American Society of Regional Anesthesia and Pain Medicine (ASRA) [17], and its design followed the INACSL standards of best practice [21]. In addition to the institutional procedure, each service had a quick-reference card next to the LAST kit. The same medium-fidelity simulator (Resusci Anne, with SimPad PLUS and SimSTART monitor, Laerdal Medical, Stavanger, Norway), operated by a simulation technician, and real clinical equipment and drugs were used in every session. The case progressed from early neurological signs to cardiovascular instability and, if the lipid emulsion bolus was not given within the expected time, to cardiac arrest in a shockable rhythm. The intervention is reported in full, according to the elements recommended for simulation research [20], in Additional file 4.

At the technical level, the team was expected to recognise the toxicity early, call for help in a structured way, prepare and give 20% lipid emulsion, avoid contraindicated drugs and start advanced life support. The non-technical objectives were leadership, role allocation, closed-loop communication, sharing the mental model aloud, voicing doubts or disagreement regardless of professional category, integrating the HCA into the response and receiving the help team. The script included moments that required the active involvement of each team member. Only the five members of the initial team received the initial clinical information, and the help team entered the room only when called.

Session, co-facilitation and interprofessional debriefing

The seven phases of the session had fixed timings and totalled 180 minutes (Additional file 5). The prebriefing began by establishing the conditions for psychological safety, making clear that the activity was formative and non-evaluative; it then presented the objectives and the confidentiality rules and set up the fiction contract [22]. The debriefing used an interprofessional co-debriefing model, conducted by an anaesthetist and a nurse; it lasted 40 minutes and followed the PEARLS model [23]. The script was standardised (Additional file 6) and started from the facilitators' records on the observation grid (Additional file 7). Both co-facilitators were simulation instructors, so that they would model the collaboration the intervention sought to develop [24], and the debriefing included a phase devoted to the operational role of the HCA, in line with the Sim-IPE standard [8]. The facilitator pair did not change throughout the study. Two pilot sessions with professionals outside the sample preceded the study, and their data were not analysed.

Fidelity, ecological validity and standardisation of the intervention

The intervention was designed so that each team would train under the conditions in which it responds to a real crisis. Following the INACSL simulation design standard [21], three dimensions of fidelity and ecological validity were considered, as summarised in Additional file 8. Physical (structural) fidelity concerns the environment and equipment: real clinical equipment and drugs, the lipid emulsion kit and emergency trolley in their usual location in the service, a medium-fidelity simulator and the same spatial layout at every delivery site. Conceptual fidelity corresponds to the clinical coherence of the case, built from the institutional procedures and the ASRA checklist, with a programmed physiological progression. For psychological fidelity, the aim was for participants to act as they would in reality, through the fiction contract, initial information restricted to the first-line team, a help team kept outside the room until called, and each participant performing their own professional role. Finally, ecological validity reflects the correspondence between the team trained and the real team: full composition, professionals and procedures from the participants' own services, and the HCA within the critical path of the response. This distinction rests on a view of simulation as social practice

with physical, semantic and phenomenal modes [25] and on evidence that the authenticity of tasks and roles matters more for transfer of learning than equipment realism [26–28].

The intervention was held constant across eleven predefined operational parameters (scenario, simulator, equipment and drugs, learning objectives, scenario duration, debriefing model and duration, session structure and timings, facilitation team, technical team, data collection instruments and spatial layout) and was checked against the Sim-IPE standard and the associated standards for prebriefing, facilitation, debriefing and outcomes [8, 29–32] (Additional file 8). Figure 2 shows the environment briefing and the debriefing circle.

Instruments administered to participants

The ICCAS was the central measure. It has 20 items scored from 1 (poor) to 5 (excellent), for a total of 20 to 100 points, across six domains: communication, collaboration, roles and responsibilities, patient- and family-centred approach, conflict management and team functioning [15, 16]. It was administered immediately before the scenario and immediately after the debriefing, rather than in the retrospective format in which it was validated [16], to avoid the recall and social desirability bias of reconstructing the baseline retrospectively [33]; the trade-off is a possible shift in the frame of reference between the two administrations. The final administration also included item 21, the global transition item of the revised instrument, in which participants compare their current ability to collaborate interprofessionally with their ability before the activity, from "much better − 1" to "much worse − 5", in the opposite direction to the other items [16, 33]. This item is a retrospective measure of perceived change, independent of the pre-post difference.

Readiness for interprofessional learning was measured before the session with the four-subscale version of the Readiness for Interprofessional Learning Scale (RIPLS), 19 items scored from 1 to 5 [34, 35]. It was used to characterise each category and not as a measure of change, because of its ceiling effect [36]. Items 10 to 12 were reversed (Y = 6 - X) so that higher scores indicate a more favourable attitude in every subscale.

Knowledge of LAST was assessed before and after the session with a 15-item multiple-choice questionnaire scored from 0 to 100% (Additional file 9), developed according to Bloom's taxonomy and reviewed to consensus in a focus group of seven external experts (two anaesthetists, two nurses, two HCAs and one simulation specialist) with an independent moderator; no content validity index was calculated. The questionnaire was the same for the three categories. HCAs were not expected to have clinical knowledge, and their scores are reported but not interpreted as clinical knowledge.

After the session, the Simulation Effectiveness Tool-Modified (SET-M), in the version validated for Brazilian Portuguese, assessed perceived effectiveness [37, 38]; the observer item was excluded because all participants had an active role, leaving 19 items scored from 1 to 3 in the prebriefing, learning, confidence and debriefing domains. Its final open-ended question invited participants to add anything they wished about the experience. The Debriefing Assessment for Simulation in Healthcare (DASH), in the DASH Participant Version, Short Form, assessed debriefing quality with six elements scored from 1 to 7 (total of 42 points) [39]. Because no validated European Portuguese versions exist, the RIPLS and the ICCAS were used in English, the SET-M in its Brazilian version [38] and the DASH in the Portuguese translation provided by the Center for Medical Simulation. Questionnaires were completed electronically, and each participant created the code used to pair their own responses.

Facilitators' records of team behaviour

During each scenario, the two facilitators completed the same structured observation grid (Additional file 7) independently and without communicating with each other, recording expected actions, the team members involved and

time metrics for each scenario state. The grid was built to support the debriefing and was not validated. The two records of each session agreed on all elements extracted for this analysis: the timing of the call for help, leadership, the use of cognitive aids (LAST procedures), the mode, duration and causes of delay of the initial lipid emulsion bolus, the scenario pathway, closed-loop communication and the tasks performed by the HCA.

Sample size and statistical analysis

All analyses were exploratory. Scale and questionnaire scores are presented as mean ± standard deviation; categorical variables and the ICCAS global item, a single ordinal item answered only after the session, are presented as absolute and relative frequencies. Differences between categories were analysed with the Kruskal-Wallis test and, for sex and previous simulation experience, with Pearson's chi-square test; pre-post change within each category was analysed with the Wilcoxon signed-rank test. Tests were run in IBM SPSS Statistics (version 30), and p values, without correction for multiple comparisons, serve as a descriptive reference with a threshold of 0.05. The open-ended SET-M answers were examined by conventional content analysis [40]: two coders, one of whom facilitated the sessions, independently assigned each comment to a theme and resolved disagreements by consensus.

The sample size calculation addressed the first question of the trial, the comparison between settings: with $d = 0.60$, $\alpha = 0.05$ and power of 0.80, a two-tailed independent-samples t test (G*Power 3.1.9.7) required 45 participants per setting, and 49 were included to form complete teams of seven. The unit of analysis was the participant for the questionnaires and the team for the facilitators' records. With 14 teams and a single HCA in each, multilevel models would not have estimated the between-team variance with precision, so participant-level tests were used and interpreted descriptively. The electronic form could not be submitted until every item had been answered, so there were no missing data.

Results

Participants and readiness for interprofessional learning by category

Twenty-eight anaesthetists, 56 nurses and 14 HCAs took part, with no withdrawals, exclusions or adverse events. The categories differed in age and professional experience ($p < 0.001$ for both) but not in sex distribution ($p = 0.186$). No HCA had previously taken part in clinical simulation, unlike 89.3% of anaesthetists (25 of 28) and 39.3% of nurses (22 of 56) ($p < 0.001$) (Table 1).

Table 1
Sample characteristics and readiness for interprofessional learning (RIPLS) by professional category

Sociodemographic and professional data	Anaesthetists (n = 28)	Nurses (n = 56)	HCAs (n = 14)	p*
Age (years)	36.75 ± 6.31	46.80 ± 9.54	44.86 ± 13.17	**< 0.001***
Sex, n	M 4; F 24	M 11; F 45	M 0; F 14	0.186**
Professional experience (years)	10.89 ± 6.52	24.07 ± 9.43	15.43 ± 10.14	**< 0.001***
Previous clinical simulation experience, n (%)	25 (89.3)	22 (39.3)	0 (0.0)	**< 0.001****
RIPLS (before the session)				
Teamwork and collaboration [1–9]	43.82 ± 2.16	41.34 ± 3.48	37.79 ± 8.10	**< 0.001***
Negative professional identity [10–12], reversed	14.36 ± 1.22	13.04 ± 2.44	10.36 ± 3.69	**< 0.001***
Positive professional identity [13–16]	19.11 ± 1.40	17.11 ± 2.12	15.71 ± 3.52	**< 0.001***
Roles and responsibilities [17–19]	8.82 ± 1.36	9.38 ± 1.92	10.21 ± 2.58	**0.015***
Total	86.11 ± 4.89	80.86 ± 6.58	74.07 ± 13.84	**< 0.001***

Note: age, professional experience and RIPLS expressed as mean ± standard deviation; sex and previous simulation experience as absolute frequency (percentage). *Kruskal-Wallis H non-parametric test. $p < 0.05$ statistically significant. **Pearson's chi-square test for categorical data (sex and previous simulation experience). $p < 0.05$ statistically significant.

The total RIPLS score differed between categories ($p < 0.001$): it was highest in anaesthetists (86.11 ± 4.89), intermediate in nurses (80.86 ± 6.58) and lowest in HCAs (74.07 ± 13.84). The same gradient was observed in the teamwork and collaboration subscale and in both professional identity subscales. The roles and responsibilities subscale followed the opposite direction, with the highest score in HCAs (10.21 ± 2.58) and the lowest in anaesthetists (8.82 ± 1.36; $p = 0.015$).

Interprofessional collaborative competencies before and after the session

Before the session, the total ICCAS score did not differ between categories ($p = 0.679$), nor did any domain (Table 2). In anaesthetists, the total rose from 68.75 ± 8.28 to 79.68 ± 9.88 ($p < 0.001$), and in nurses from 69.43 ± 11.71 to 79.52 ± 12.44 ($p < 0.001$), with an increase in all six domains in both categories ($p \leq 0.001$). In HCAs, the total went from 72.79 ± 19.95 to 77.50 ± 19.52 ($p = 0.382$), with no change in any domain (p between 0.238 and 0.915) and high standard deviations at both time points. After the session, the three categories did not differ in the total ($p = 0.966$) or in any domain.

Table 2
Interprofessional collaborative competencies (ICCAS) and global change item by professional category

Communication [1–5]	**Anaesthetists (n = 28)**	**Nurses (n = 56)**	**HCAs (n = 14)**	**p***
Before	17.46 ± 2.44	17.75 ± 3.53	18.00 ± 5.72	0.772
After	20.07 ± 2.97	20.00 ± 3.57	20.07 ± 5.34	0.831
p**	**< 0.001**	**< 0.001**	0.238	
Collaboration [6–8]				
Before	10.46 ± 1.45	10.44 ± 2.03	11.07 ± 3.08	0.701
After	11.82 ± 1.66	12.04 ± 2.02	12.07 ± 2.46	0.734
p**	**0.001**	**< 0.001**	0.363	
Roles and responsibilities [9–12]				
Before	13.64 ± 1.97	13.64 ± 2.39	14.21 ± 4.35	0.527
After	16.25 ± 1.97	16.05 ± 2.54	15.92 ± 3.81	0.949
p**	**< 0.001**	**< 0.001**	0.283	
Patient- and family-centred approach [13–15]				
Before	9.75 ± 1.58	9.96 ± 2.02	10.71 ± 2.87	0.554
After	12.25 ± 1.51	11.25 ± 1.97	10.71 ± 3.45	0.863
p**	**< 0.001**	**< 0.001**	0.915	
Conflict management [16–18]				
Before	10.64 ± 1.52	10.86 ± 1.99	11.50 ± 2.44	0.485
After	12.21 ± 1.60	12.23 ± 1.82	11.50 ± 3.39	0.948
p**	**< 0.001**	**< 0.001**	0.858	
Team functioning [19–20]				
Before	6.79 ± 1.13	6.77 ± 1.41	7.29 ± 2.20	0.488
After	8.07 ± 1.21	7.95 ± 1.62	7.21 ± 2.39	0.601
p**	**< 0.001**	**< 0.001**	0.865	
Total				
Before	68.75 ± 8.28	69.43 ± 11.71	72.79 ± 19.95	0.679
After	79.68 ± 9.88	79.52 ± 12.44	77.50 ± 19.52	0.966

Note: ICCAS domains and total expressed as mean ± standard deviation; global change item expressed as n (%). *Kruskal-Wallis H non-parametric test. $p < 0.05$ statistically significant. **Wilcoxon non-parametric test for paired samples. $p < 0.05$ statistically significant. Global change item, answered after the session only: "Compared with before the learning activities, would you say that your ability to collaborate interprofessionally is..." On the form, "much better" was coded 1 and "much worse" 5. Worsening responses may reflect either a genuine perception of worse collaboration or misreading of the reversed coding; the data do not allow the two to be distinguished.

Communication [1–5]	Anaesthetists (n = 28)	Nurses (n = 56)	HCAs (n = 14)	p*
p**	**< 0.001**	**< 0.001**	0.382	
Global change item, n (%)				
Much better	9 (32.1%)	29 (51.8%)	6 (42.9%)	
A little better	17 (60.7%)	21 (37.5%)	3 (21.4%)	
The same	2 (7.1%)	2 (3.6%)	1 (7.1%)	
A little worse	0	3 (5.4%)	0	
Much worse	0	1 (1.8%)	4 (28.6%)	
Better or much better	26 (92.9%)	50 (89.3%)	9 (64.3%)	

Note: ICCAS domains and total expressed as mean ± standard deviation; global change item expressed as n (%). *Kruskal-Wallis H non-parametric test. p < 0.05 statistically significant. **Wilcoxon non-parametric test for paired samples. p < 0.05 statistically significant. Global change item, answered after the session only: "Compared with before the learning activities, would you say that your ability to collaborate interprofessionally is..." On the form, "much better" was coded 1 and "much worse" 5. Worsening responses may reflect either a genuine perception of worse collaboration or misreading of the reversed coding; the data do not allow the two to be distinguished.

Perceived change on the ICCAS global item

On the global item, 26 of the 28 anaesthetists and 50 of the 56 nurses considered that their ability to collaborate interprofessionally was better or much better than before the session. Among HCAs, 9 of the 14 gave the same answer, 1 considered it unchanged and 4 marked "much worse"; four nurses marked one of the worsening options (Table 2).

Knowledge of LAST

Knowledge scores differed between categories before and after the session (p < 0.001 at both time points) and increased in all three (Table 3): from 95.71 ± 11.65% to 99.52 ± 1.75% in anaesthetists (p = 0.026), from 83.57 ± 12.45% to 92.50 ± 7.58% in nurses (p < 0.001) and from 34.29 ± 21.86% to 53.33 ± 30.38% in HCAs (p = 0.025).

Table 3
LAST knowledge questionnaire by professional category, before and after the session

Before the session (%)	Anaesthetists (n = 28)	Nurses (n = 56)	HCAs (n = 14)	p*
	95.71 ± 11.65	**83.57 ± 12.45**	**34.29 ± 21.86**	**< 0.001**
After the session (%)	99.52 ± 1.75	92.50 ± 7.58	53.33 ± 30.38	**< 0.001**
p value**	**0.026**	**< 0.001**	**0.025**	

Note: values expressed as mean ± standard deviation of the percentage of correct answers. *Kruskal-Wallis H non-parametric test. p < 0.05 statistically significant. **Wilcoxon non-parametric test for paired samples. p < 0.05 statistically significant.

Perception of the educational experience

DASH scores were high in all three categories and did not differ between them in the total (p = 0.747) or in any element (Table 4). The SET-M total did not differ either (p = 0.102), but HCAs gave lower scores to the learning domain (14.29 ±

3.15, compared with 16.46 ± 2.32 in anaesthetists and 15.73 ± 1.91 in nurses; p = 0.022) and to the debriefing domain (13.57 ± 1.74, compared with 14.82 ± 0.77 and 14.79 ± 0.59; p < 0.001).

Table 4
Perceived simulation effectiveness (SET-M) and debriefing quality (DASH) by professional category

SET-M	**Anaesthetists (n = 28)**	**Nurses (n = 56)**	**HCAs (n = 14)**	**p value***
Prebriefing	5.39 ± 1.03	5.38 ± 0.95	5.57 ± 0.85	0.703
Learning	16.46 ± 2.32	15.73 ± 1.91	14.29 ± 3.15	**0.022**
Confidence	15.82 ± 2.45	16.90 ± 2.23	13.79 ± 3.62	0.077
Debriefing	14.82 ± 0.77	14.79 ± 0.59	13.57 ± 1.74	**< 0.001**
Total	52.50 ± 5.24	51.98 ± 4.34	47.21 ± 7.88	0.102
DASH Participant Version, Short Form				
Element 1: introduction	6.71 ± 0.60	6.66 ± 0.55	6.36 ± 0.93	0.439
Element 2: learning environment	6.75 ± 0.65	6.64 ± 0.52	6.50 ± 0.85	0.294
Element 3: debriefing structure	6.61 ± 0.63	6.63 ± 0.56	6.57 ± 0.76	0.994
Element 4: reflection on performance	6.61 ± 0.69	6.52 ± 0.60	6.36 ± 0.93	0.592
Element 5: strengths and areas to improve	6.57 ± 0.63	6.52 ± 0.66	6.57 ± 0.56	0.824
Element 6: performance improvement	6.71 ± 0.53	6.64 ± 0.55	6.57 ± 0.56	0.809
Total	39.96 ± 3.00	39.61 ± 2.86	38.93 ± 4.60	0.747
Note: values expressed as mean ± standard deviation. *Kruskal-Wallis H non-parametric test.				
p < 0.05 statistically significant.				

Forty-seven participants (48.0%) wrote a comment with content: 14 anaesthetists, 26 nurses and 7 HCAs. The most frequent theme was the request for repeated and regular training (17 comments, present in all three categories), followed by teamwork and communication (8) and learning and safety to ask (8); two comments referred to organisation and realism, one to emotional discomfort, and eleven were thanks with no other content (Additional file 10). One anaesthetist wrote that "in certain situations, interprofessional simulation adds value compared with simulation within the same professional group", and one HCA wrote: "I learned to be more effective and to always ask when I do not know, so as not to make mistakes".

Team behaviour during the scenario

In all 14 teams, the call for help was made in the first state of the scenario, during the neurological changes and before cardiovascular instability. Leadership was taken without hesitation in 13 teams; in one there was initial uncertainty about who was leading. Situational awareness was maintained in all teams, and closed-loop communication was recorded with some failures. In every team, the HCA transported the blood gas samples, called the help team when asked and brought the emergency trolley, and the facilitators recorded that these tasks freed the clinical professionals for clinical management. The LAST kit was brought by the HCA in some teams and by a nurse in the others, when the HCA was busy with another task.

All teams consulted a procedure for the administration of lipid emulsion. In 7 teams the initial bolus was completed within the expected time and the scenario stabilised: six teams injected the emulsion with syringes and one used a free-flow infusion completed in less than three minutes. In the other 7, administration took longer than the recommended time and the scenario progressed to cardiac arrest, because of difficulty in calculating the infusion rate needed to give the bolus in three minutes (four teams) or in handling the infusion pump (three teams).

The two cognitive aids gave different times for the initial bolus: one minute on the quick-reference card next to the kit, in line with the European Resuscitation Council [41], and two to three minutes in the institutional procedure, in line with the ASRA [17, 42]. Both are current and both require a rapid bolus, and neither stated the mode of administration, the equipment, the infusion rate or the number of professionals required. This discrepancy was observed incidentally in the first session, in both institutions, and was not a study outcome. The documents were not changed during data collection; from the first session, the facilitators presented both indications in every debriefing, and the discrepancy was reported to those responsible at the end of the sessions in each institution.

Discussion

Main findings

Teams whose members differed widely in simulation experience and readiness for interprofessional learning reported similar perceptions of collaborative competency before and after a single interprofessional simulation session. Anaesthetists and nurses reported higher competency in all ICCAS domains; in HCAs the pre-post change was inconclusive, although most reported on the global item that they collaborated better. The facilitators recorded an early call for help and a redistribution of tasks in every team, and closed-loop communication that was not always performed. All results are exploratory: the questionnaires measure reaction and perceived learning, and the facilitators' records describe behaviour in simulation.

The whole team as the unit of interprofessional learning

Interprofessional simulation almost always rests on the doctor-nurse dyad [7, 9], whereas here the perioperative anaesthetic emergency team trained and was evaluated as it responds to a crisis, in line with the frameworks' definition of collaborative practice [2, 3]. Having the three categories in the same room would not by itself have made the session interprofessional; it was the shared interprofessional objectives, interprofessional co-debriefing and the phase devoted to the HCA's role that gave it that character. This brought into the same session professionals with very different starting points: 39.3% of nurses and 89.3% of anaesthetists had previous simulation experience, but no HCA did, and readiness for interprofessional learning followed a similar gradient. Because experience largely coincides with professional category, the effect of one cannot be separated from that of the other. Such heterogeneity is inherent to IPE with the whole team and places greater demands on the prebriefing, where psychological safety is established for every member [22].

Despite these differences, perceived collaborative competency converged across the three categories and debriefing quality was rated in the same way. In anaesthetists and nurses, the ICCAS increased in all domains, as described after other interprofessional interventions [43]. Without a control group, this convergence cannot be attributed to the session, but it is consistent with an intervention built to the Sim-IPE standard, with explicit interprofessional objectives and interprofessional co-facilitation [8], and it shows that a single intervention with the same objectives for everyone was received in a similar way by very different members of the team.

Interdependence and closed-loop communication

The facilitators' records add what the questionnaires do not measure. In every team, tasks were distributed so that the clinical professionals remained free for clinical decisions: the HCA was part of the critical path of the response, and when the HCA was busy, a nurse fetched the LAST kit. This redistribution of tasks according to workload is the mutual support that team research considers central, and it depends on each member knowing the tasks and limits of the others, knowledge that is built by training with the people one works with [11]. Professionals trained in real anaesthesia teams have reported transfer to practice and asked for all members to take part [44], and in this study an anaesthetist commented on the added value of interprofessional simulation.

The same records show the limit of this interdependence: closed-loop communication was not always performed. This is the type of failure that observation in the operating theatre associates with loss of information [1], and it is a behaviour of the team as a whole that none of the instruments used measures. Interprofessional self-efficacy is a plausible antecedent of readiness to speak up and to call for help, and psychological safety is a condition for such behaviours [14, 22, 45]. However, self-assessments correlate poorly with observed performance [46], and the authors of the ICCAS validation advocate collecting behavioural data [16]. Team behaviour should therefore be the object of structured observation in future studies.

Measuring IPE in a team that includes HCAs

The inclusion of HCAs exposed a mismatch between definition and measurement: the frameworks include support staff, but IPE instruments were developed and validated in clinical professions. The inconclusive ICCAS result in HCAs allows three explanations, which are not mutually exclusive. The first is group size: with 14 participants and standard deviations close to 20 points, only large changes would be detectable. The second is item suitability, since some competencies, such as the patient-centred approach or the negotiation of overlapping responsibilities, are outside the scope of this professional group's duties. The third is the initial self-assessment: these professionals started from the highest mean value, with wide dispersion, and without previous simulation experience; those who do not yet know the standard against which they will be judged tend to overestimate their competence [46, 47]. A similar pattern was described in assistant nurses in an intensive care unit [13].

The global item helps to interpret this result. The pre-post difference assumes the same frame of reference at both time points, whereas the global item asks for a direct judgement of change made with the frame of reference acquired during the session; it is less sensitive to this recalibration, although more exposed to social desirability and recall [33, 47]. In anaesthetists and nurses the two measures agreed, and in HCAs they diverged, which is consistent with the third explanation and indicates that an absence of pre-post change does not mean an absence of perceived change. The HCAs' answers were nevertheless polarised, and worsening responses also appeared in four nurses. These responses may reflect a genuine perception of worse collaboration, since a first simulated crisis can expose gaps that participants had not recognised [45, 47], and in HCAs this would be consistent with their lower SET-M ratings of learning and debriefing; they may also reflect misreading of an item coded in the opposite direction to the others. The data do not allow these explanations to be distinguished, and future studies should keep the same orientation throughout the instrument. The knowledge questionnaire raises a similar issue: it had a ceiling effect in anaesthetists, and in HCAs the increase indicates, at most, greater familiarity with the event. Finally, the roles and responsibilities subscale of the RIPLS, the only one on which HCAs scored highest, had low reliability in the Danish validation that included assistant nurses [48].

Educational experience and interprofessional co-facilitation

In a debriefing with three professional categories and very different simulation experience, the high and homogeneous DASH scores suggest that interprofessional co-facilitation created conditions perceived as adequate by all members. This did not translate in the same way into the perceived contribution to learning: on the SET-M, HCAs gave less value to

the debriefing and to learning. The two results are compatible, because the DASH assesses the facilitators' behaviour and the SET-M what participants feel they have gained. Psychological safety is not evenly distributed in interprofessional teams [49], the SET-M items refer to clinical judgement, outside the scope of HCAs, and this was their first simulation. Co-facilitators model the collaboration they aim to train [24], and interprofessional facilitation guidelines have been shown to increase the contribution of nurse facilitators and to shift debriefing towards teamwork [50]. The phase devoted to the HCA's role sought to give a voice to those who rarely have one; the SET-M results suggest that it needs more time.

Implications for education, assessment and organisation

The implications lie at three levels. At the educational level, simulation-based IPE programmes should include the professionals who actually take part in the response, and not only the categories most represented in training and research. In this study, the heterogeneous starting points placed greater demands on the prebriefing, and the less favourable rating of the debriefing by HCAs suggests that the phase devoted to their role needs more time and explicit objectives for this category. At the assessment level, the results lie at the levels of reaction and perceived learning. Until self-report instruments have been validated with all professional groups, their results should neither be compared across categories nor read in isolation; structured observation of the team is the necessary complement, because current instruments rarely assess how the team functions as a whole [10].

At the level of organisation and safety, the Østergaard Declaration proposes that simulation-based education be governed as part of the healthcare infrastructure and evaluated by team performance and patient safety [51]. Training with the services' own equipment and documents showed that the procedures gave the target time for the lipid emulsion bolus but not how to achieve it, and the delays observed came from putting the administration into practice. Six of the seven teams that met the time used syringes, the method described by the American College of Medical Toxicology (ACMT), which reserves the infusion pump for the subsequent infusion [52]. Cognitive aids could therefore also state the mode of administration, the equipment, the allocation of tasks and, when a pump is used, the rate already calculated for body weight. From a clinical governance perspective, observations of this kind can inform the revision of procedures, but this study did not assess whether any changes were made or with what effect.

Limitations

For the question addressed in this article there was no control group, so the observed change cannot be attributed to the session with confidence. Same-day pre-post measurement may have been influenced by social desirability, familiarity with the questionnaires and a shift in the frame of reference [47], particularly because the ICCAS was administered prospectively [16]. Two instruments were answered in English, none has been validated for European Portuguese and none was developed for support staff. The HCA group is small and underpowered to detect moderate changes. Self-report instruments rarely capture relational or systemic learning [53].

The facilitators' records come from a non-validated observation grid, created and completed by the two facilitators, who knew the study objectives and then led the debriefing; agreement was checked by direct comparison, although the elements extracted are observable events rather than performance ratings. Closed-loop communication was recorded as a global judgement for each team rather than for each exchange, and the extraction of these records was not pre-specified. Half of the participants wrote comments, and one of the two coders facilitated the sessions. The data were analysed by participant without modelling the dependence within teams, so p values tend to overstate the evidence, and multiple tests were performed without correction. Finally, the team studied is the one that responds to an anaesthetic event and was formed for the study, so the results do not extend to crises involving the surgical team.

Future research

Structured observation grids will need to be adapted and validated for the whole team, and time metrics, such as the time to the call for help and to the first dose of lipid emulsion, defined in advance, so that team behaviour can be analysed as an outcome rather than only described [54]. IPE instruments need to be validated with every professional group in the team and adapted to European Portuguese. Studies with a comparison group, larger samples of each category and models that take the team structure into account will allow the effect of the intervention to be estimated with more confidence. Longitudinal follow-up, with institutional safety indicators, is needed to reach Kirkpatrick levels 3 and 4 and to find out whether early calling for help is sustained, given that it deteriorated at six months in another LAST simulation programme [18]. Finally, prior definition of indicators and structured monitoring of outcomes are what translational simulation programmes most often lack [55], and what happens after a system problem is identified in simulation and reported to those responsible should be followed up.

Conclusions

This study shows that the perioperative anaesthetic emergency team can be trained in its full composition, in an interprofessional intervention built to the Sim-IPE standard, with teams from two working services. Professionals with very different starting points, including HCAs with no previous simulation experience, rated the debriefing similarly and ended the session with close perceptions of collaborative competency. In anaesthetists and nurses, the session was associated with higher self-reported collaborative competency in all domains. HCAs placed less value on what they learned in the debriefing, so the session also has to be prepared for those taking part for the first time.

Observation of the team added what the questionnaires did not measure. The HCA was part of the critical path of the response, and the redistribution of tasks left the clinical professionals free for clinical decisions. Closed-loop communication was not always performed and is unlikely to be consolidated in a single session; participants from all three categories asked, in fact, for the training to be repeated regularly. Training with the services' real resources also exposed gaps in the cognitive aids, which depend on the documents and equipment available rather than on each professional's knowledge.

In HCAs, the absence of pre-post change, in contrast with the change perceived on the global item, shows that IPE instruments do not yet capture the experience of every member of the team. By training and evaluating the whole team, the study extends simulation-based IPE beyond the doctor-nurse dyad. The next step is to measure collaboration with instruments validated for all its professional groups and to observe whether what is learned in simulation reaches practice.

Abbreviations

ACMT
American College of Medical Toxicology
ASRA
American Society of Regional Anesthesia and Pain Medicine
BO-ULSM
Operating Theatre, Unidade Local de Saúde de Matosinhos
DASH
Debriefing Assessment for Simulation in Healthcare
HCA
healthcare assistant
ICCAS
Interprofessional Collaborative Competency Attainment Survey

IPE
interprofessional education
LAST
local anaesthetic systemic toxicity
PEARLS
Promoting Excellence and Reflective Learning in Simulation
RIPLS
Readiness for Interprofessional Learning Scale
SET-M
Simulation Effectiveness Tool-Modified
Sim-IPE
simulation-enhanced interprofessional education
SIMFMUP
Simulation Centre, Faculty of Medicine, University of Porto
UPA-ULSSJ
Post-Anaesthesia Care Unit, Unidade Local de Saúde de São João

Declarations

Ethics approval and consent to participate:

The Ethics Committee of the Faculty of Medicine of the University of Porto and RISE-Health approved the study (393/CEFMUP-RISEHealth/2025), as did the Health Ethics Committees of Local Health Unit of Matosinhos (process 20250125, with authorisation from the Board of Directors) and of Local Health Unit of São João (process 53/2026). The study was conducted in accordance with the Declaration of Helsinki and the General Data Protection Regulation. Every participant gave written, free and informed consent. No patients or patient data were involved.

Consent for publication:

All professionals who appear in Fig. 2 gave written informed consent for publication of the images.

Competing interests:

The authors declare that they have no competing interests.

Additional files

Additional file 1

Changes to the trial protocol and pre-specified and post hoc elements of this analysis (.docx).

Additional file 2

Completed CONSORT 2025 checklist with the CONSORT extension for healthcare simulation research (.docx).

Additional file 3

LAST clinical scenario (.docx).

Additional file 4

Reporting of the simulation-based intervention according to the elements of Cheng et al. (.docx).

Additional file 5

LAST simulation session plan (.docx).

Additional file 6

Standardised PEARLS debriefing script (.docx).

Additional file 7

Structured facilitators' observation grid (.docx).

Additional file 8

Fidelity, ecological validity and compliance of the intervention with the Sim-IPE standard (.docx).

Additional file 9

LAST knowledge questionnaire (.docx).

Additional file 10

Themes of the SET-M open-ended comments by professional category (.docx).

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Author Contribution

All authors have made substantial contributions to the manuscript, namely:• MCC conceived and designed the study, obtained the ethical approvals, prepared the study documents, recruited the participants, co-facilitated the sessions and debriefings, collected and analysed the data, and drafted the manuscript;• JJS co-supervised the study, contributed to the development of the clinical scenario, the knowledge questionnaire and the standardised debriefing script, co-facilitated the sessions and debriefings, and reviewed the manuscript;• RR contributed to the development of the clinical scenario and the standardised debriefing script, and reviewed the manuscript;• AN supervised the study, contributed to its conception, methodological design and statistical approach, analysed the data, acted as specialist simulation technician, and reviewed the manuscript;• All authors reviewed it critically;• All authors have approved the manuscript version submitted and agree with its submission.

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Data Availability

The dataset is not publicly available. Participants consented to statistical processing and to the dissemination of results only in aggregated, anonymised form by professional group, so individual data cannot be shared. The aggregated data behind the results presented here can be obtained from the corresponding author on justified request. Records are kept on a secure, restricted-access institutional server of the Faculty of Medicine of the University of Porto for up to one year after the end of the study, as approved by the ethics committee, and are then irreversibly erased. Additional files include the knowledge questionnaire, clinical scenario, debriefing script, observation grid and session plan.

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Figures

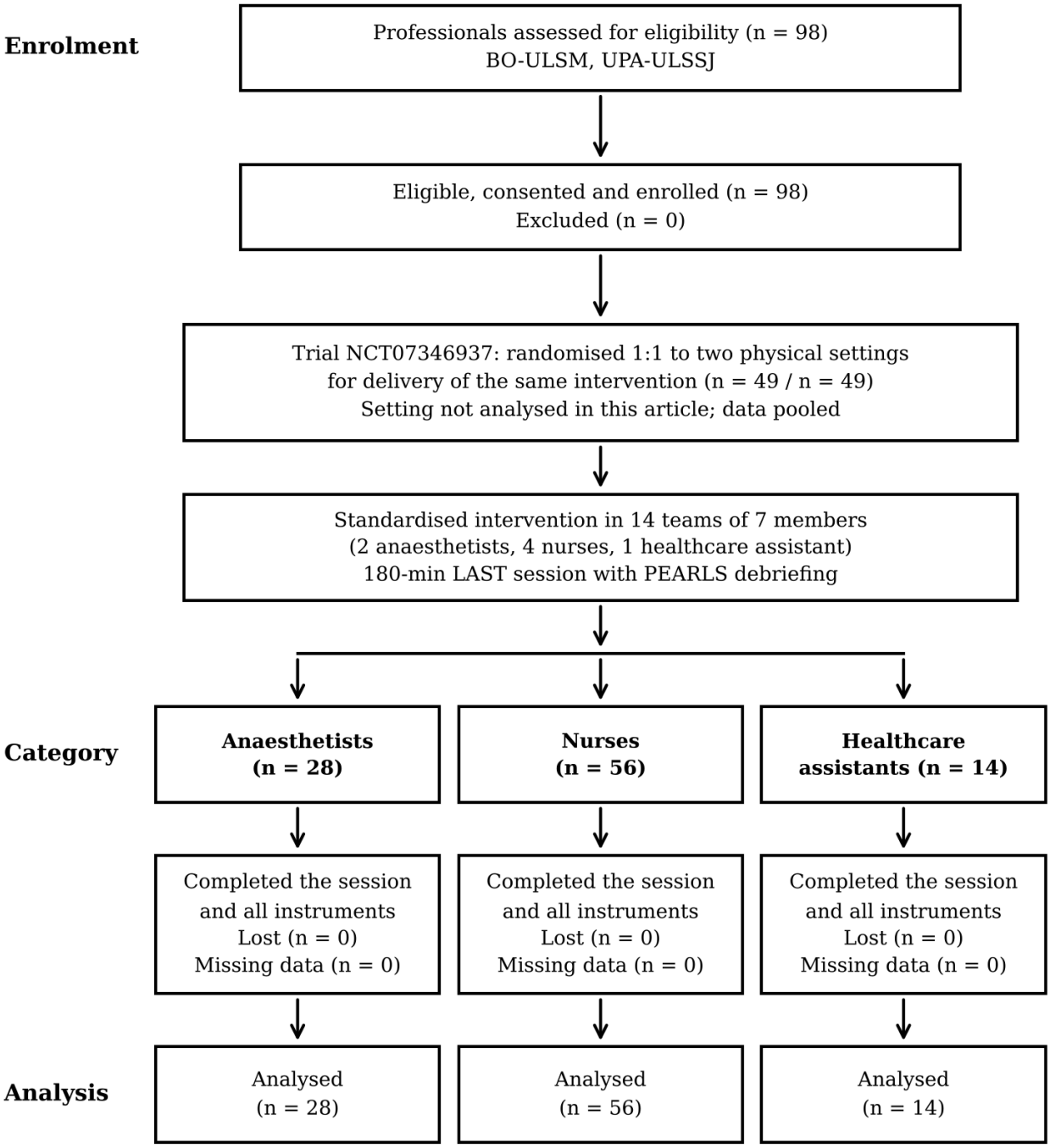

Figure 1

Flow of participants from enrolment to analysis by professional category

In the trial, participants were allocated to two delivery sites for the same intervention. Setting is not the object of this analysis and the data were pooled. There were no exclusions, losses or missing data.



Figure 2

Moments of the interprofessional simulation session with the perioperative anaesthetic emergency team

A: environment briefing led by the two facilitators (centre, by the monitor, and right, by the bed), to familiarise the seven-member team with the simulator and the space before the scenario. B: the interprofessional debriefing circle, with anaesthetists, nurses and an HCA. Published with written informed consent from all professionals visible.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalFile1Changestothetrialprotocolandprespecifiedandposthocelementsofthisanalysis.docx
- AdditionalFile8FidelityecologicalvalidityandcomplianceoftheinterventionwiththeSimIPEstandard.docx
- AdditionalFile5LASTsimulationsessionplan.docx
- AdditionalFile9LASTknowledgequestionnaire.docx
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- AdditionalFile4Reportingofthesimulationbasedintervention.docx
- AdditionalFile10ThemesoftheSETMopenendedcommentsbyprofessionalcategory.docx
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