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SIMULATION-BASED TRAINING COMPARED TO TRADITIONAL TEACHING FOR ADULT ANAPHYLAXIS MANAGEMENT: A STUDY AMONG NURSING STUDENTS IN MOROCCO

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Abstract

Background: Anaphylaxis is a serious medical emergency that can quickly progress to cardiorespiratory arrest if not diagnosed and treated promptly. Nurses, who are often on the front line in dealing with this emergency, play a crucial role in ensuring rapid treatment. In this regard, training nursing students in the management of anaphylaxis is crucial. Simulation has been shown to be an effective teaching strategy. Therefore, this study aimed to evaluate the impact of simulation on knowledge acquisition and retention, the development of technical and non-technical skills, and anxiety reduction among undergraduate nursing students at the Higher Institute of Nursing Professions and Health Techniques (HINPHT) in Fez, Morocco. **Methods:** An interventional study with an experimental group and a control group was conducted with 49 nursing students. The experimental group (n=25) received traditional training in anaphylaxis management (theoretical course and demonstration) and simulation training, while the control group (n=24) received only traditional training. Data were obtained using a questionnaire on theoretical knowledge, a technical skills assessment grid, the TEAM (Team Emergency Assessment Measure) global descriptive scale for assessing non-technical skills, and the State-Trait Anxiety Inventory (STAI-Y1 and STAI-Y2). **Results:** The results of the post-test of theoretical knowledge immediately after simulation were significantly superior in the experimental group (16,51 ± 1,49) out of 20 compared to the control group (13,50 ± 1,89). The assessment of technical skills on manikins showed a considerable advantage for the experimental group (27, 24 ± 1,45) out of 30 compared to the control group (16, 08 ± 0,95). Thus, the results revealed a significant difference between the TEAM score of the experimental group (38, 88 ± 2, 60) out of 44 and that of the control group (22, 42 ± 1, 01). In addition, the results of the post-test of the STAI-Y1 scale revealed a significant reduction in situational anxiety in the experimental group, with an average score of 30, 08 ± 1,35 out of 80, compared to the control group's score (43, 08 ± 1, 41). **Conclusion:** The results showed that the use of simulation in training for the management of anaphylaxis was more effective than the traditional method in terms of knowledge acquisition and retention, development of technical and non-technical skills, and reduction of anxiety among undergraduate nursing students.

Keywords: *Anaphylaxis; Anxiety; Knowledge; Morocco; Non-technical skills; Nursing students; Simulation; Technical skills.*

Introduction

Anaphylaxis is a severe systemic hypersensitivity reaction that develops rapidly and can lead to serious respiratory and/or circulatory dysfunction, which can be life-threatening if not treated immediately [1]. It is one of the most common medical emergencies encountered in emergency departments and intensive care units worldwide [2]. Anaphylaxis progresses rapidly and can lead to serious complications, including cardiac arrest [3].

In this context, the speed and effectiveness of the therapeutic response are of paramount importance. There is a close link between the severity of anaphylaxis and the quality of care, with rapid and appropriate intervention being a determining factor in reducing mortality [4]. Conversely, late diagnosis or inadequate therapeutic response is often associated with avoidable psychological, social, and health

burdens, as well as a significant increase in costs to the healthcare system [5].
Nurses, who are often the first responders to patients in these critical situations, have a central role in the early recognition of anaphylaxis and the rapid initiation of therapeutic measures [6]. However, studies show that newly graduated nurses, due to their limited clinical experience, can be quickly destabilized when faced with an episode of anaphylaxis, thereby delaying the implementation of appropriate treatment and compromising patient survival [7]. Furthermore, it is widely documented that nursing students often have incomplete knowledge and insufficiently mastered practices regarding the management of anaphylaxis, which can limit their ability to intervene effectively in high-risk situations [8] .
This initial knowledge deficit is frequently accompanied by difficulty in maintaining knowledge over time. Indeed, knowledge retention remains problematic, as shown by Atalla and al. (2025), who report a rapid decline in knowledge in the absence of active teaching strategies. This lack of consolidation has a direct impact on performance in real-life situations, limiting students' ability to effectively apply procedures in emergency contexts [9].
This lack of knowledge directly affects the mastery of technical skills that are essential in the management of anaphylaxis, such as the correct administration of epinephrine, securing the airway, and continuous monitoring of vital signs. A deficit in these skills can lead to delays or errors, thereby compromising patient safety [7,10].
In addition, optimal management of anaphylaxis also requires non-technical skills, including rapid decision-making, situational awareness, teamwork, leadership, and effective communication. These skills play a crucial role in coordinating care and preventing errors in critical situations, but their integration into training programs remains limited, perpetuating worrying shortcomings [11].
Furthermore, the combination of insufficient knowledge, limited technical skills, and deficits in non-technical skills tends to increase students' anxiety levels when confronted with unfamiliar clinical environments or complex situations. This anxiety, which is particularly pronounced during initial encounters with critical scenarios, can impair decision-making, slow down interventions, and consequently compromise patient survival [12].
In this context, nursing student training aims to prepare them to intervene effectively in clinical settings where the management of life-threatening emergencies is an essential skill. However, despite solid theoretical training, opportunities for practical exposure to these critical situations remain limited [13].
Given this lack of practical opportunities, simulation is an innovative and appropriate educational solution for developing and strengthening nursing students' skills. It allows for realistic scenarios without risk to the patient, promotes experiential learning, repetition of technical procedures, and training in non-technical skills, while helping to reduce anxiety related to managing emergency situations [14–16].
In this regard, several studies have confirmed the effectiveness of simulation in improving clinical performance in life-threatening emergencies, particularly in the management of anaphylaxis, a critical situation where speed of action and coordination are essential [17]. However, most studies focus on isolated aspects, such as knowledge or technical skills. Few studies have examined the impact of simulation on all the determining factors in an integrated manner, including knowledge, technical and non-technical skills, and students' anxiety in this type of critical situation. Furthermore, some research still highlights worrying gaps in the preparation of future professionals for the management of anaphylaxis, illustrating the need for enhanced and targeted educational approaches [18].
This study aims to fill this gap by evaluating the impact of simulation on knowledge acquisition and retention, the development of technical and non-technical skills, and the reduction of anxiety among nursing students at the Higher Institute of Nursing and Health Techniques of Fez in relation to the management of anaphylaxis in adults, with a view to continuously improving nursing training and strengthening preparedness for life-threatening emergencies.

Materials & Methods

Study population

The study population consisted of all students at the Higher Institute of Nursing Sciences and Health Technology in Fez (HINPHT) in the fourth semester of the professional license cycle; Option: Nurse in Emergency and Intensive Care (NEIC) and Nurse in Anesthesia and Reanimation (NAR) of the 2021-2024 class, who had not yet taken the anaphylaxis course. 58 students were included. This sample size was not determined a priori by a power calculation, but corresponds to an exhaustive recruitment of all eligible students from the 2021-2024 class (option: NAR and NEIC) who have not yet received the course on anaphylaxis. The participants in this study share the same educational objectives for the fourth-semester resuscitation module. The anaphylaxis course is part of this module. The selection criteria for study participants were established to exclude all students who had already taken the anaphylaxis course or who had practiced anaphylaxis management in a clinical or simulation setting. Of the 58 students who fulfilled the eligibility criteria, 49 were available and were included in the study

Study design and setting

This study was designed as an interventional study with an equivalent control group, before and after simulation training. It aimed to compare the experimental group and the control group in terms of differences in knowledge acquisition and retention, development of technical and non-technical skills, and changes in anxiety levels when managing anaphylaxis. The experimental group was trained using simulation, while the control group received only traditional theoretical training.

The training lasted three consecutive days and was conducted at the simulation center of the Faculty of Medicine, Pharmacy, and Dentistry in Fez. The teaching team consisted of a professor of anesthesia and resuscitation at the Faculty of Medicine, Pharmacy, and Dentistry and the principal investigator.

The protocol was structured around seven methodological steps.

First step

The first stage was carried out on the first day of training, with 49 students attending to participate in the study and 9 absent. This stage consisted of administering a theoretical knowledge questionnaire (pre-test) on the management of anaphylaxis, structured in two parts. The first part focused on sociodemographic data, while the second part assessed theoretical knowledge related to the management of emergency situations. Subsequently, participants completed the State-Trait Anxiety Inventory-Y2 (STAI-Y2) to assess trait anxiety.

The questionnaires were completed using a unique alphanumeric identifier, freely chosen by each student during the training. This ensured anonymity while guaranteeing the correspondence of responses across the different stages of the study.

Second step

The second step involved theoretical and practical training for the 49 students, focusing on the management of anaphylaxis. The practical component was designed to enable students to acquire essential technical skills (diagnosis, oxygen therapy, and therapeutic administration) through workshops supervised by trainers. This one-day session aimed to ensure that all students had the same basic skills before the simulation exercise.

Third step

The third step was devoted to the immediate assessment of theoretical knowledge acquisition at the end of the theoretical course. This assessment, carried out on all 49 students, was conducted using the same questionnaire as the pre-test.

Fourth step

The fourth step consisted of randomizing participants into the experimental and control groups using stratified randomization based on their training program (NAR and NEIC) to ensure a balanced representation of both options between the groups. Numbers 1 (experimental group) and 2 (control group) were written on identical slips of paper, folded to make the contents invisible, and then mixed in an opaque urn. Each student personally drew their number without prior knowledge of their assignment. The draw was conducted separately for NAR students (n=28; 14 assigned to the experimental group, 14 to the control group) and NEIC students (n=21; 11 to the experimental group, 10 to the control group), according to a predetermined allocation ratio close to 1:1 (25 vs. 24), without creating successive blocks. The teaching team was unaware of the participants' assignments before the draw, as no correspondence list had been established beforehand.

Students who drew number 1 were assigned to the experimental group (n = 25), receiving simulation-based training, while those who drew number 2 were assigned to the control group (n = 24), receiving only traditional theoretical instruction. Each group was then subdivided into subgroups of four to five students, resulting in a total of twelve subgroups: six for the experimental group (five subgroups of four students and one of five), coded A1 to A6, and six for the control group (each composed of four students), coded B1 to B6. At the end of this stage, the two groups were comparable across all relevant characteristics: number of participants, educational level, theoretical knowledge assessed in the immediate post-test, and prior practical experience related to the emergency situation under study.

Due to the nature of the intervention, blinding the participants was not feasible. The assessment of technical and non-technical skills (TEAM score), conducted during the sixth stage, was performed live, at the bedside of the simulated patient, by the same trainers who had supervised and debriefed the simulation sessions; these evaluators were therefore not blinded to the group assignments. The scoring was carried out collaboratively by the two evaluators, resulting in a common score for each criterion, without independent ratings.

Each participant was assigned an individual alphanumeric code within their subgroup, ensuring the confidentiality of their identity throughout the study. However, membership in the experimental or control group remained identifiable during data entry and analysis, as these were not performed blinded to the assigned group.

Fifth step

The fifth step was the simulation exercise for the experimental group on a high-fidelity mannequin simulator, on the second day of the training. During this stage, a scenario relating to the emergency situation studied was carried out by the experimental group. This scenario was validated by professors of anesthesia and intensive care at the Faculty of Medicine, Pharmacy, and Dental Medicine in Fez, who are specialists in anesthesia and intensive care and experts in the field. Each subgroup of four to five students carried out the scenario. All participants enrolled in this simulation session as active actors in order to avoid the bias of the observer role on the self-assessment results. Thus, the composition and order of the teams were decided randomly and a number was assigned to each subgroup.

Before the session began, all students in the experimental group were asked to complete the State-Trait Anxiety Inventory-Y1 (STAI-Y1) to assess their level of situational anxiety specific to managing the emergency situation addressed.

The simulation session itself was conducted in a traditional manner, including an initial briefing phase, the practical simulation, and then a debriefing of each subgroup by the trainers, which was carried out directly at the patient's bedside immediately after each simulation. The students were accompanied by a nurse facilitator (provided by the principal investigator).

Immediately after the debriefing, all participants in the experimental group completed the questionnaires: the theoretical knowledge questionnaire and the STAI-Y1.

Sixth step

The sixth stage consisted of a structured practical assessment, the aim of which was to objectively measure the development of technical and non-technical skills among students in both groups: the experimental group (which benefited from the simulation) and the control group (without simulation). This assessment, carried out on the third day of the study, was based on the same scenario used in the previous stage.

Each subgroup, whether experimental or control, was assessed using a specific grid focusing on technical skills. At the same time, non-technical skills were assessed using the TEAM (Team Emergency Assessment Measure) Global Descriptive Scale, recognized for its validity in the context of simulated emergency situations.

In order to better understand the impact of the simulation on the emotional state of the participants, all students were asked to complete the STAI-Y1 questionnaire before the scenario was carried out, in order to assess their immediate level of anxiety in response to the emergency situation. The same instrument was administered immediately after the simulation to measure changes in anxiety in response to exposure to the simulated clinical situation.

Seventh step

The seventh step of the protocol focused on assessing knowledge retention, carried out one month after the initial training. Thirty days after the intervention, all participants (N = 49) from both the experimental and control groups were invited to participate in a new evaluation phase. This step aimed to measure the retention of theoretical knowledge related to the management of anaphylaxis.

Data collection

This study relied on four data collection instruments. The sociodemographic questionnaire for students included characteristics such as sex, age, nationality, option, prior knowledge of anaphylaxis management, and practical experience gained during clinical placements or simulation sessions.

The State-Trait Anxiety Inventory (STAI-Y), originally developed by Spielberger, Gorsuch, Lushene, Vagg, and Jacob in 1983 [19], was subsequently translated and validated in French [20]. It is a self-administered questionnaire composed of two distinct parts, each comprising 20 statements. The first part, Form Y-1, assesses state anxiety, defined as how an individual feels at a specific moment, using a four-point Likert scale ranging from “Not at all” to “Very much so.” The second part, Form Y-2, measures trait anxiety, referring to the general tendency of an individual to experience anxiety, also rated on a four-point Likert scale ranging from “Almost never” to “Almost always.” Scores for each part range from 20 to 80 and are obtained by summing the points assigned to each item, with higher scores indicating greater anxiety. The study conducted by Gauthier and Bouchard in 1993 validated both the quality of the translation and the relevance of the STAI-Y as a tool for measuring anxiety [20]. The questionnaire was completed under the same code name chosen by each student during training, which allowed comparison of results across phases.

The anaphylaxis knowledge questionnaire: This questionnaire, administered as a pre-test and post-test, was developed by the principal investigator based on the updated recommendations of the World Allergy Organization [1], the American Academy of Allergy, Asthma & Immunology [21] and the European Academy of Allergy and Clinical Immunology [22], as well as current literature and validated by professors of anesthesia and intensive care at the Faculty of Medicine, Pharmacy, and Dental Medicine in Fez, specialists in anesthesia and intensive care, and experts in the field. The questionnaire consisted of 20 multiple-choice questions (1 point was awarded for the correct answer and 0 for the incorrect answer). The questionnaire was graded out of 20 and was completed under the same code name that each student chose during the training course in order to allow for comparison of results.

The technical skills assessment grid for anaphylaxis : This grid focused on technical skills for managing anaphylaxis in adults. It was developed based on current literature and international recommendations from the World Allergy Organization [1], he American Academy of Allergy, Asthma & Immunology [21], and the European Academy of Allergy and Clinical Immunology [22], as well as current literature. It was prepared with input from experienced experts. This grid consisted of 30 items covering various aspects of care, namely: diagnosis, alert, and management. The technical skills assessment grid also included three other items concerning the preparation and administration of prescribed medications, adherence to aseptic and hygiene protocols, and adherence to professional attire requirements. The following scoring method was adopted: Each group received 1 point for each of the 30 skill items that they performed correctly and in the correct order, 0.5 points for incomplete performance requiring improvement, and no points for failure to perform the skill item or for performing it incorrectly. Technical skill scores ranged from 0 to 30 correct elements of anaphylaxis management.

The non-technical skills assessment scale:

We used the TEAM (Team Emergency Assessment Measure) global descriptive scale. This is a validated global descriptive scale for assessing the performance of an interprofessional team in a critical care setting [23–25]. It has the distinction of having a validated French version [26]. It is the most recognized and reliable descriptive measurement tool in its field, consisting of 11 items divided into three categories: leadership (sum of items 1 and 2), teamwork (sum of items 3-9), and task management (sum of items 10 and 11). Each item describes a variety of possible behaviors, rated from 0 (Never/Almost Never) to 4 (Always/Almost Always). By combining the 11 items, an overall TEAM score from 0 to 44 is obtained. The TEAM scale also includes a Global Team Performance (GTP) score, which is different from the overall TEAM score and is rated on a scale of 1 to 10. This GTP score enables a global assessment that goes beyond technical skills and critical situation management [26].

Data analysis methods

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) software, version 27. Quantitative variables were presented as mean ± standard deviation, while qualitative variables were expressed as numbers and percentages. Changes in theoretical knowledge, technical skills, non-technical skills, and anxiety at different times during the study, in the experimental and control groups, were assessed using the paired t-test. The comparison of mean scores between the two groups was performed using the independent samples t-test. A statistical significance threshold of $p < 0.05$ was used for all analyses. In addition, a post-hoc power analysis was performed using SPSS v.27 (two-tailed t-test for independent samples) for two of the primary outcome measures. Regarding non-technical skills (TEAM score), the comparison between the experimental group (n=25; M=38,88 ± 2,62) and the control group (n=24; M=22,42 ± 1,02) revealed a mean difference of 16,46 points, a very large effect size (Cohen's d = 8,22), and a statistical power of 1,00 (100%). Regarding the retention of theoretical knowledge at one month, the comparison between the two groups (M=15,58 ± 1,78 vs M=11,42 ± 1,96) revealed a mean difference of 4,16 points, a Cohen's d of 2,23, and a power of 1,00 (100%), with a two-sided alpha threshold of 0,05.

The normality of the distributions was verified separately for each group using the Shapiro-Wilk test. Some quantitative variables followed a normal distribution in both groups; for variables exhibiting a deviation from normality in at least one group, a sensitivity analysis using the Mann-Whitney U test was performed in addition to the parametric t-test, confirming the conclusions obtained by the latter in all cases. The homogeneity of variances was verified using Levene's test for each comparison between groups. In case of violation of this hypothesis, Welch's correction (unequal variances) was applied. Furthermore, since the scores for technical skills, non-technical skills (TEAM scale) and anxiety regarding the management of anaphylaxis were assessed at the subgroup level (six subgroups of four to five students per arm) rather than at the individual level, a complementary sensitivity analysis was performed at the subgroup level, the appropriate unit of observation for these criteria, using an exact Mann-Whitney U test comparing the six experimental subgroups to the six control subgroups.

Ethical considerations

This study is part of a larger research project that has been approved by the Fez University Hospital Ethics Committee, Laboratory of Minimally Invasive Surgery, Robotics, Artificial Intelligence, and Educational Innovations, Faculty of Medicine, Pharmacy, and Dentistry of Fez, Hassan II University Hospital Center (date: 12/15/2022, n°32/22), as well as authorization from the Regional Directorate of Health and Social Protection of Fez-Meknes (date: 10/26/2022, n°5997). All students who agreed to participate signed a written informed consent form before data collection began. Participation was entirely voluntary, and responses were treated as strictly confidential. Participants could withdraw from the study at any time.

Results

The results revealed that 49 nursing students participated in the study. They were randomly assigned to either the experimental group (14 NAR and 11 NEIC) or the control group (14 NAR and 10 NEIC), resulting in 25 students in the simulation group and 24 students in the control group. Thirty-seven (75, 5%) women and 12 (24,5%) men participated in the study. The average age of the students was 19,92 years (SD = 0,99). The majority of participants were Moroccan (n = 46, 93,90%), and three students were foreign (6,10%). All study participants reported that they had no prior knowledge or practical experience in the management of anaphylaxis in adults (Table I). For the experimental group, there was a significant improvement in average theoretical knowledge scores between the different assessment times. However, there was a significant decrease in average theoretical knowledge scores between the post-test after the simulation training and the post-test one month after the training (Table II).

Table I. Sociodemographic characteristics of participants

Variables	Total (N=49) n (%)
Sex	
Female	37 (75,5%)
Male	12 (24,5%)
Nationality	
Moroccan	46 (93,9%)
Foreigner	3 (6,1%)
Option	
NAR	28 (57,14%)
NEIC	21 (42,85%)
Average age M (SD)	19,92 (0,99)

M: Mean; SD: Standard Deviation; NAR: Nurse in Anesthesia and Reanimation; NEIC: Nurse in Emergency and Intensive Care.

Table II. Evolution of theoretical knowledge of the experimental group

Comparison	Score out of 20 M ± SD	Mean difference ± SD	95% CI	t (df)	*p*	Cohen's *d* [95% CI]
Pre-test Theoretical course →Post-test after the theoretical course	7,00 ± 2,10 / 13,76 ± 2,13	-6,76 ± 2,34	[-7,73 ; -5,79]	-14,42 (24)	< 0,001	-2,88 [-3,78 ; -1,98]
Pre-test Theoretical course → Post-test after the simulation	7,00 ± 2,10 / 16,51 ± 1,49	-9,51 ± 1,76	[-10,24 ; -8,78]	-26,95 (24)	< 0,001	-5,39 [-6,95 ; -3,82]
Pre-test Theoretical course → Post-test at 1 month after the simulation	7,00 ± 2,10 / 15,58 ± 1,78	-8,58 ± 1,92	[-9,37 ; -7,79]	-22,30 (24)	< 0,001	-4,46 [-5,77 ; -3,14]
Post-test after the theoretical course → Post-test after the simulation	13,76 ± 2,13 / 16,51 ± 1,49	-2,75 ± 1,31	[-3,29 ; -2,21]	-10,49 (24)	< 0,001	-2,10 [-2,80 ; -1,38]
Post-test after the theoretical course → Post-test at 1 month after the simulation	13,76 ± 2,13 / 15,58 ± 1,78	-1,82 ± 1,51	[-2,44 ; -1,20]	-6,02 (24)	< 0,001	-1,20 [-1,71 ; -0,68]
Post-test after the simulation → Post-test at 1 month after the simulation	16,51 ± 1,49 / 15,58 ± 1,78	0,93 ± 0,88	[0,56 ; 1,30]	5,25 (24)	< 0,001	1,050 [0,55 ; 1,53]

M: Mean; SD: Standard Deviation; CI: Confidence Interval; df, degrees of freedom.

Table III. Evolution of theoretical knowledge in the control group

Comparison	Score out of 20 M ± SD	Mean difference ± SD	95% CI	t (df)	*p*	Cohen's *d* [95% CI]
Pre-test Theoretical course →Post-test after the theoretical course	7,18 ± 1,85 13,50 ± 1,89	-6,32 ± 1,59	[-6,99 ; -5,65]	-19,47 (23)	< 0,001	-3,97 [-5,18 ; -2,76]
Pre-test Theoretical course → Post-test at 1 month after the theoretical course	7,18 ± 1,85 11,42 ± 1,96	-4,24 ± 1,45	[-4,85 ; -3,63]	-14,35 (23)	< 0,001	-2,93 [-3,85 ; -1,99]
Post-test after the theoretical course → Post-test at 1 month after the theoretical course	13,50 ± 1,89 11,42 ± 1,96	2,08 ± 0,68	[1,80 ; 2,37]	15,05 (23)	< 0,001	3,071 [2,10 ; 4,03]

M: Mean; SD: Standard Deviation; CI: Confidence Interval; df, degrees of freedom.

There was a significant improvement in mean scores in the immediate and 1-month post-test compared to mean pre-test scores for the control group. However, there was a significant decrease in mean knowledge scores between the post-test immediately following the theoretical course and the post-test at 1 month (**Table III**).

Table IV. Comparison of theoretical knowledge scores on anaphylaxis between the experimental and control groups (pre- and post-intervention)

Evaluation time	Experimental group, score (out of 20), *M* ± SD	Control group, score (out of 20), *M* ± SD	Mean difference [95% CI]	*t (df)*	*p*	Cohen's *d* [95% CI]
Pre-test Theoretical course	7,00 ± 2,10	7,18 ± 1,86	-0,18 [-1,32 ; 0,96]	-0,312 (47)	0,756	-0,09 [-0,65 ; 0,47]
Pre-test Theoretical course	13,76 ± 2,13	13,50 ± 1,89	0,26 [-0,90 ; 1,42]	0,451 (47)	0,654	0,13 [-0,43 ; 0,69]
Post-test after Intervention [1]	16,51 ± 1,50	13,50 ± 1,89	3,01 [2,03 ; 3,99]	6,191 (47)	<0,001	1,77 [1,10 ; 2,43]
Post-test at 1month	15,58 ± 1,78	11,42 ± 1,96	4,16 [3,09 ; 5,24]	7,792 (47)	<0,001	2,23 [1,50 ; 2,94]

[1] *For the experimental group: immediately after the simulation; for the control group: immediately after theoretical instruction.*
M: Mean; SD: Standard Deviation; CI: Confidence Interval; df, degrees of freedom.

No statistically significant difference was observed between the mean theoretical knowledge scores of the experimental and control groups during the pre-test (p = 0.756; d = −0.09) and the first post-test (p = 0.654; d = 0.13). However, when comparing knowledge acquisition scores on anaphylaxis management, students in the experimental group, who received both theoretical instruction and practical simulation, obtained significantly higher scores on the second theoretical knowledge post-test than those in the control group, which received only theoretical training (p < 0.001; d = 1.77). When assessing retention one month after training, the mean knowledge retention scores were significantly higher for the experimental group than for the control group (p < 0.001; d = 2.23) (**Table IV**).

Table V. Comparison of technical skills in anaphylaxis between the experimental and control groups

Technical skills scores			Experimental group, *M* ± SD	Control group, score *M* ± SD	Mean difference [95% CI]	*t (df)*	*p*	Cohen's *d* [95% CI]
Diagnostic/13	Medical interview and physical examination	Past Medical History (PMH)	12,52 ± 0,71	7,42 ± 1,27	5,10 [4,51 ; 5,70]*	17,29 (35,99)*	< 0,001	4,99 [3,84 ; 6,14]
		Context (Non-Steroidal Anti-Inflammatory Drug injection)						
		Cutaneous and mucosal signs						
		Hemodynamic signs						
		Respiratory signs						
		Gastrointestinal signs (vomiting)						
	Monitoring	Heart rate						
		Cardiac rhythm						
		Blood pressure						
		Respiratory rate						

	SpO₂ (oxygen saturation) Temperature Urine output						
Alert the doctor early /1		0,92 ± 0,19	0,67 ± 0,24	0,25 [0,13 ; 0,38]*	4,10 (43,41)*	< 0,001	1,18 [0,56 ; 1,78]
Management /13	Reassure the patient Discontinuation and elimination of the suspected agent Supine position with elevation of the lower limbs Upper airway clearance Oxygen therapy Two peripheral intravenous lines Upon medical prescription: Adrenaline by titration; Vascular filling with crystalloids; β2-agonists; Corticosteroid therapy; Immediate laboratory tests: Histamine (Anaphylaxis) (EDTA tube); Tryptase (Anaphylaxis) (EDTA tube / serum tube); Specific IgE (Causative agent) (serum tube)	11,64 ± 0,96	7,25 ± 0,26	4,39 [3,98 ; 4,80]*	22,00 (27,49)*	< 0,001	6,17 [4,80 ; 7,53]
Prepare and administer prescribed medications /1		0,72 ± 0,25	0,25 ± 0,25	0,47 [0,32 ; 0,62]	6,47 (47)	< 0,001	1,85 [1,17 ; 2,51]
Adhere to aseptic and hygiene protocols /1		0,68 ± 0,24	0,25 ± 0,39	0,43 [0,24 ; 0,62]*	4,60 (38,43)*	< 0,001	1,33 [0,70 ; 1,94]
Adhere to professional attire requirements /1		0,76 ± 0,25	0,25 ± 0,39	0,51 [0,32 ; 0,70]*	5,39 (39,38)*	< 0,001	1,55 [0,91 ; 2,19]
Global score /30		27,24 ± 1,46	16,08 ± 0,95	11,16 [10,45 ; 11,86]*	31,83 (41,49)*	< 0,001	9,02 [7,11 ; 10,92]

M: Mean; SD: Standard Deviation; CI: Confidence Interval; df, degrees of freedom.
**Levene's test significant for all these variables → row with unequal variances systematically retained. Mann-Whitney individual level (n=25 vs 24), overall score: p < 0.001 (confirmed). Sensitivity analysis at the subgroup level (n=6 vs 6, truly independent unit), overall score: U = 0, exact p = 0.002 (complete separation between the two groups).*

The experimental group obtained significantly higher scores than the control group for each of the dimensions of technical skills assessed, as well as for the overall score ($p < 0.001$ for all comparisons). The sensitivity analysis performed at the subgroup level, considered as independent assessment units, produced consistent results, with a complete separation of distributions between the two arms of the study (exact $p = 0.002$) (**Table V**).

Table VI. Comparison of non-technical skills between the experimental and control groups

Categories of the TEAM scale	Experimental group M ± SD	Control group M ± SD	Mean difference [95% CI]	*t (df)*	*p*	Cohen's *d* [95% CI]
Overall TEAM score (0-44)	38,88 ± 2,62	22,42 ± 1,02	16,46 [15,31 ; 17,61]*	29,21 (31,34)*	< 0,001	8,22 [6,47 ; 9,96]
Teamwork (0-28)	23,48 ± 1,50	14,58 ± 0,83	8,90 [8,20 ; 9,60]*	25,78 (37,69)*	< 0,001	7,29 [5,71 ; 8,85]
Leadership (0-8)	7,76 ± 0,60	3,92 ± 0,28	3,84 [3,57 ; 4,11]*	28,98 (34,52)*	< 0,001	8,17 [6,43 ; 9,91]
Task management (0-8)	7,64 ± 0,57	3,88 ± 0,45	3,76 [3,47 ; 4,06]*	25,79 (45,32)*	< 0,001	7,33 [5,75 ; 8,91]
GPS (0-10)	8,48 ± 0,51	4,88 ± 0,45	3,60 [3,33 ; 3,88]*	26,31 (46,65)*	< 0,001	7,50 [5,88 ; 9,10]

M: Mean; SD: Standard Deviation; CI: Confidence Interval; df: degrees of freedom; TEAM: Team Emergency Assessment Measure; GPS: Global Performance Score.
**Levene's test significant for all 5 scores (p ≤ 0.027) → line with unequal variances systematically retained. Mann-Whitney U test at the individual level: p < 0.001 for all 5 scores (confirmed). Sensitivity analysis at the subgroup level (n=6 vs 6): U = 0, exact p = 0.002 for all 5 scores (complete separation).*

Non-technical skills were significantly higher in the experimental group across all dimensions of the TEAM scale, with an exceptionally large effect size for the overall score ($d = 8.22$). The convergence between individual results and the sensitivity analysis at the subgroup level confirms the robustness of this effect (**Table VI).**

Table VII. Intragroup evolution of state anxiety scores (STAI-Y1)

Group	Comparison	Score out of 80 M ± SD	Mean difference [95% CI]	*t* (*df*)	*p*	Cohen's *d* [95% CI]
Expérimental	Pre-simulation Test → Post-simulation Test	40,72 ± 1,90 → 35,36 ± 1,91	5,36 [4,28 ; 6,44]	10,26 (24)	< 0,001	2,05 [1,35 ; 2,74]
	Pre-simulation Test → Pre-test Evaluation by Simulation	40,72 ± 1,90 → 35,20 ± 2,06	5,52 [4,41 ; 6,63]	10,24 (24)	< 0,001	2,05 [1,34 ; 2,74]
	Pre-simulation Test → Post-test Evaluation by Simulation	40,72 ± 1,90 → 30,08 ± 1,35	10,64 [9,81 ; 11,47]	26,36 (24)	< 0,001	5,27 [3,73 ; 6,80]
	Post-simulation Test → Pre-test Evaluation by Simulation	35,36 ± 1,91 → 35,20 ± 2,06	0,16 [-0,86 ; 1,18]	0,32 (24)	0,750	0,06 [-0,33 ; 0,46]
	Post-simulation Test → Post-test Evaluation by Simulation	35,36 ± 1,91 → 30,08 ± 1,35	5,28 [4,36 ; 6,20]	11,85 (24)	< 0,001	2,37 [1,59 ; 3,14]
	Pre-test Evaluation by Simulation → Post-test Evaluation by Simulation	35,20 ± 2,06 → 30,08 ± 1,35	5,12 [4,24 ; 6,00]	12,03 (24)	< 0,001	2,41 [1,62 ; 3,19]
Control	Pre-test Evaluation by Simulation → Post-test Evaluation by Simulation	41,38 ± 1,46 → 43,08 ± 1,41	-1,71 [-2,49 ;-0,93]	-4,52 (23)	< 0,001	-0,92 [-1,39 ; -0,43]

M: Mean; SD: Standard Deviation; CI: Confidence Interval; df: degrees of freedom; STAI- Y1: State Trait Anxiety Inventory Y-1 form, measures situational anxiety

For the experimental group, mean anxiety scores decreased significantly between the pre-test and the various post-training assessments (p < 0.001). No significant difference was observed between the post-test of the simulation training and the pre-test of the simulation assessment (p = 0.750). In contrast, a significant decrease was noted between the pre-test and the post-test of the simulation assessment, as well as between the two post-tests (p < 0.001). For the control group, a significant increase in mean anxiety scores was observed between the pre-test and the post-test during the simulation assessment (**Table VII**). Both groups exhibited comparable trait anxiety and situational anxiety levels before any intervention (p = 0.829 and p = 0.163), confirming the initial equivalence of the groups. After the intervention, the experimental group showed significantly lower anxiety than the control group at each subsequent measurement time (p < 0.001), suggesting an anxiolytic effect of simulation training (**Table VIII).**

Table VIII. Comparison of anxiety scores related to anaphylaxis management between the experimental and control groups (pre-& post-intervention)

Measure		Experimental group M ± SD	Control group M ± SD	Mean difference [95% CI]	*t* (*df*)	p (t-test)	p (Mann-Whitney)	Cohen's *d* [95% CI]
Anxiety (STAI-Y2) (Score out of 80)		38,80 ± 2,14	38,92 ± 1,56	-0,12 [-1,20 ; 0,96]	-0,22 (47)	0,829	0,847	-0,06 [-0,62 ; 0,50]
Anxiety (STAI-Y1) (Score out of 80)	Pre-simulation Test (Experimental group)/ Pre-test Evaluation by Simulation (Control group)	40,72 ± 1,90	41,42 ± 1,50	-0,70 [-1,69 ; 0,29]	-1,42 (47)	0,163	0,173	-0,40 [-0,97 ; 0,16]
	Post-simulation Test (Experimental group)/ Post-test Evaluation by simulation (Control group)	35,36 ± 1,91	43,04 ± 1,37	-7,68 [-8,64 ;-6,72]	-16,12 (47)	< 0,001	< 0,001	-4,61 [-5,68 ;-3,52]
	Pre-test Evaluation by Simulation	35,20 ± 2,06	41,38 ± 1,47	-6,17 [-7,21 ; -5,14]	-12,03 (47)	< 0,001	< 0,001	-3,44 [-4,32 ; -2,54]
	Post-test Evaluation by Simulation	30,08 ± 1,35	43,08 ± 1,41	-13,00 [-13,80 ; -12,21]	-32,94 (47)	< 0,001	n/a‡	-9,41 [-11,39 ; -7,43]

M: Mean; SD: Standard Deviation; CI: Confidence Interval; df: degrees of freedom; STAI-Y2: State-Trait Anxiety Inventory, Form Y2 – measures trait anxiety; STAI-Y1: State-Trait Anxiety Inventory, Form Y1 – measures situational anxiety

‡The IASTA score (Simulation Assessment form y-1) followed a normal distribution in both groups (experimental and control). Subgroup sensitivity analysis (n=6 vs 6) confirmed the robustness of the main analysis results: significant differences between groups were observed for anxiety after simulation, before and after simulation assessment (U = 0; two-sided exact p = 0.002 for each of these comparisons), while no significant difference was observed for baseline trait anxiety (U = 14.5; p = 0.615) or for anxiety before simulation (U = 10.0; p = 0.227).

Discussion

In nursing training, anaphylaxis management is a critical skill, particularly due to the speed and precision required to respond to this life-threatening emergency. Given this clinical requirement, simulation has emerged as a strategic and essential educational approach. It allows nursing students to practice in a controlled environment, without risk to the patient, while developing cognitive, technical and non-technical skills essential for effective care. Simulation not only facilitates the recognition of early signs of an anaphylactic reaction, but also promotes the lasting acquisition of priority management steps, by stimulating the emotional and cognitive engagement of learners [10].

In this regard, the aim of this study is to evaluate the impact of simulation on knowledge acquisition and retention, the development of technical and non-technical skills, and the reduction of anxiety among undergraduate nursing students when performing intensive care skills on a patient with anaphylaxis.

The results of the pre-test and post-test conducted immediately after the theoretical course on the management of anaphylaxis revealed no statistically significant difference between the mean scores of the experimental group and those of the control group. These results provided a consistent basis for comparison between the two groups. However, the results obtained after the simulation training showed a significant improvement in theoretical knowledge among students in the experimental group compared to those in the control group (Table IV).

These results are consistent with those reported by Goldsworthy et al. (2022), who also observed improved student knowledge in an international study of 88 nursing students who participated in a virtual simulation program covering various emergency situations [27]. Similarly, a greater increase in knowledge was also observed among school nurses trained in pediatric anaphylaxis through theoretical preparation followed by simulation, compared to those receiving entirely online training [28]. These results support the value of supplementing theoretical instruction with simulation to reinforce the acquisition of knowledge related to emergency case management. Indeed, by applying learned theoretical concepts to a real-life clinical situation, simulation could help learners better understand the links between clinical manifestations and the interventions to be implemented ([27,28].

From this perspective, cognitive load theory emphasizes the importance of adapting the complexity of the scenario to students' prior knowledge and limiting irrelevant demands, given the limited capacity of working memory (Lapierre et al., 2022). To this end, the pre-simulated clinical briefing aims to clarify the objectives and roles of the participants while familiarizing them with the environment, as proposed by Hakemi et al. (2023) in their pedagogical framework dedicated to anaphylaxis simulation [29]. This preparation could thus reduce the effort required to understand how the session will unfold and free up more cognitive resources for acquiring the targeted knowledge [29,30].

In addition, the results of our study showed a significant improvement in the retention of theoretical knowledge among nursing students in the experimental group, as assessed one month after their participation in a simulation focused on the management of anaphylaxis. Compared to the control group, participants who benefited from this immersive training maintained higher cognitive scores, reflecting the effectiveness of simulation in promoting lasting knowledge encoding in critical contexts (Table IV).

This result aligns with the observations of Ozel and Gezginci Akpinar (2026), who evaluated a simulation in the form of an educational escape game in emergency nursing training. In this randomized trial, students who participated in the simulation maintained significantly higher knowledge scores one month later than those who received only traditional instruction [31]. This maintenance of higher scores during a delayed assessment also supports the positive results for retention reported in several simulation studies in nursing education reviewed by Alharbi et al. (2024) [32] .

In this regard, active recall could help explain these observations. Indeed, when a simulated situation requires students to retrieve the knowledge necessary for their decisions without immediately consulting a resource, it stimulates the retrieval of that knowledge from memory. Debriefing can extend this engagement by inviting learners to clarify their answers, re-examine the knowledge they have used, and correct any misunderstandings, as illustrated by the activities proposed in the pedagogical framework on anaphylaxis by Hakemi et al. (2023) [29]. These opportunities to recall knowledge could facilitate its retrieval during subsequent assessments. This also aligns with the conclusions of a systematic review that emphasizes the value of active recall for promoting knowledge retention in health education [33].

Nevertheless, the results of our study revealed a statistically significant decrease in the mean theoretical knowledge scores of the experimental group between the immediate post-simulation assessment and the assessment performed one month later (**Table II**). A similar trend was observed in the control group, which received only theoretical instruction (**Table III**). Thus, despite the decrease observed during follow-up, knowledge scores remained higher in the experimental group than in the control group. A comparable trend has been reported in nursing students in Turkey after cardiopulmonary resuscitation training combining online instruction and practical training on a mannequin. In this study, scores decreased between the immediate assessment and the one-month assessment, while remaining higher than those measured before the training, reflecting partial retention of acquired knowledge [34].

This decrease suggests considering consolidation activities after initial training. In this regard, Trumble et al. (2024) highlight the value of distributing learning activities over time and encouraging active recall [33] . In anaphylactic shock training, spaced-out sessions could offer students new opportunities to recall necessary knowledge, apply it in a targeted scenario, and reassess their responses during debriefing. This organization would extend the reflective work undertaken during the initial session and could help maintain knowledge related to managing this emergency situation [29,33].

At the same time, our results confirm that simulation-based teaching is significantly more effective than the traditional theoretical approach for developing the technical skills necessary for emergency management, particularly during anaphylaxis **(Table V).** This observation aligns with the findings of Ren et al. (2022), which showed an improvement in simulation-based skills among newly graduated nurses after training in the management of anaphylactic shock with standardized patients [7]. These results, consistent with our findings, support the value of simulation for learning the skills necessary for emergency situations. Several pedagogical mechanisms may help explain these results. First, simulation provides a safe learning environment where students can practice critical procedures without risk to the patient. This hands-on experience is part of Kolb's experiential learning cycle, which links the simulated situation to its reflective analysis during debriefing, and then to the formulation of principles to guide future practice. For technical skills, this process could help students understand the difficulties encountered and adjust the execution of procedures in a subsequent situation [29] . Next, personalized feedback helps correct errors by specifying the adjustments needed to perform the actions. Mohsenzadeh et al. (2025) demonstrated in a randomized trial with nursing students that access to personalized video feedback, in addition to the face-to-face feedback received by both groups, was associated with higher cardiopulmonary resuscitation (CPR) proficiency scores at one week and one month [35] . These results highlight the value of individualized feedback, which allows learners to re-examine their performance and the suggested adjustments.

Finally, repeating actions after correction is an extension of this approach. It aligns with the principles of deliberate practice, which combines explicit objectives, targeted training on areas of insufficient mastery, and corrective feedback. In South Korea, nursing students observed an improvement in technical performance between two advanced resuscitation simulations in a program incorporating this approach. Applied to anaphylaxis training, this organization could guide the resumption of actions towards the identified difficulties in order to improve their execution and sequence in the management [36].

One of the key findings of this study is that students in the experimental group, who were trained using simulation, showed a significant improvement in soft skills scores compared to the control group across all categories of the TEAM scale, including teamwork, leadership, and task management (Table VI). This improvement confirms that simulation provides an environment conducive to the development of interpersonal and organizational skills, which are key elements of effective emergency management [37]. These skills are recognized as essential for reducing human error and optimizing collective response in critical situations, and they are central to the Crisis Resource Management (CRM) methodological framework adapted to emergency medicine [38]. Thus, Cánovas-Pallarés et al. (2025) showed that integrating CRM into simulation programs improves adaptive leadership, strengthens interprofessional communication, and optimizes role coordination among nursing students faced with emergency scenarios. This approach also strengthens teams' ability to anticipate needs in critical contexts, a skill that is particularly crucial for managing emergencies such as anaphylaxis.

These findings are also highlighted in the meta-analysis by Sánchez-Marco et al. (2023), which demonstrates that educational programs focused on soft skills, mainly based on simulation, significantly improve communication, stress management, and collective decision-making, while reducing the risk of errors during life-saving interventions. Similarly, Lee and Lee (2022) have shown that simulation applied to neonatal resuscitation promotes the simultaneous acquisition of technical and non-technical skills, particularly leadership and cooperation, which are transferable to other emergency situations such as the management of a severe anaphylactic reaction. In this light, the improvement in soft skills observed in our study can be attributed to simulation's ability to strengthen collective decision-making and stress management in emotionally charged scenarios. By exposing students to realistic anaphylaxis situations, they were able to practice maintaining clear communication, effectively distributing responsibilities, and acting in a concerted manner under pressure, thus confirming the observations of Armijo-Rivera and González (2025) that simulation is an essential educational tool for preparing future nurses to collaborate effectively and ensure a coordinated response in life-threatening emergencies.

Moreover, in our study, the initial results of trait anxiety scores (State-Trait Anxiety Inventory: STAI-Y2), measured before the start of the theoretical course, showed no statistically significant difference between the experimental group and the control group.

These results ensured equivalent starting conditions for the subsequent comparison of results.
In addition, the study results showed a significant decrease in mean situational anxiety scores (State-Trait Anxiety Inventory: STAI-Y1) between simulation training and simulation assessment for the experimental group (Table VII). Nevertheless, for the control group, which received only theoretical training, a significant increase in mean situational anxiety scores (STAI-Y1) was observed between the pre-test and post-test during the simulation assessment (Table VII). In addition, the simulation method proved to be significantly more effective than the traditional teaching method in reducing the situational anxiety levels of nursing students (Table VIII), confirming the beneficial role of simulation in regulating anxiety [43].
Furthermore, these results are consistent with the observations of Klein et al. (2025), who showed that exposure to realistic scenarios in a controlled environment not only improves cognitive and emotional preparedness, but also reduces anxiety symptoms in the face of medical emergencies. Similarly, Clements and Hardy (2025) report that simulation provides a progressive learning context that allows students to become accustomed to the emotional pressure of clinical situations, which facilitates anxiety management during critical events.
However, previous work highlights that anxiety is not necessarily a negative factor, as moderate levels can improve preparedness and promote engagement in learning [46]. Furthermore, some research indicates that initial anxiety, when properly regulated, can become a driver of concentration and efficiency, confirming that the goal is not its total elimination, but its management to make it a teaching tool [47].
The results of our study also align with the findings of Clements and Hardy (2025), according to whom individual management strategies such as preparation, mental rehearsal, and mindfulness contribute to reducing anxiety. Integrating these approaches into the simulation program could not only enhance the effectiveness of the intervention but also optimize its ability to mitigate anxiety in highly emotional contexts, such as anaphylaxis.
Furthermore, the significant reduction in anxiety in the experimental group could have positive repercussions beyond the simulation. According to Klein et al. (2025), emotional preparation acquired in a controlled setting can translate into better clinical performance and more effective decision-making in real-life situations. Moreover, as Clements and Hardy (2025) point out, supportive supervision and a collaborative environment not only promote anxiety reduction but also the consolidation of self-confidence and non-technical skills, essential for emergency management.
All of these contributions cognitive, practical, emotional, and relational share a common pedagogical goal: to prepare students to apply their learning in clinical practice. Simulation can support this transfer by allowing them to experience care situations, analyze their actions, and identify reusable strategies. This perspective is illustrated by medical and nursing students who reported using communication and collaboration strategies developed through simulation in their clinical practice [48].

Strengths

This study is distinguished by the authors' motivation and commitment to exploring the significant role of simulation training in nursing education. It represents a first initiative to evaluate the impact of simulation as an innovative teaching method on knowledge acquisition and retention, technical and non-technical skills development, and anxiety reduction in the management of anaphylaxis in adults by nursing students at HINPHT in Fez.

Limitations

This study has several limitations. It was conducted in a single institution (ISPITS of Fez), with a sample limited to nursing students (N=49), which restricts its generalizability to other institutions or programs; therefore, it is recommended to replicate it on a larger scale, particularly in several training institutes in Morocco. The follow-up, limited to one month, does not allow for the assessment of longer-term retention, and the study was restricted to educational criteria evaluated in a simulated context, without assessing real clinical outcomes. Furthermore, a Hawthorne effect cannot be ruled out, as the awareness of being observed may have influenced the behavior of students in both groups. Finally, although post-hoc power analyses indicate maximum power for the two primary outcomes (Cohen's d > 1.8), this value should be interpreted with caution since it stems from already highly significant effects and does not compensate for the overall limited sample size.

Conclusion

Simulation-based anaphylaxis management training improved nursing students' theoretical knowledge acquisition and retention. Furthermore, simulation was found to have a positive effect on the development of technical and non-technical skills and the reduction of student anxiety. The results of this study support the implementation of simulation as a dynamic teaching strategy. It is suggested that these sessions be offered periodically to continually reinforce and update students' knowledge and skills in anaphylaxis management.

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