Leal-Costa, C., Carrasco-Guirao, J. J., Adánez-Martínez, M. G., Díaz-Agea, J. L., Ramos-Morcillo, A. J., Ruzafa-Martínez, M., Suarez-Cortes, M., & Jiménez-Ruiz, I. (2023). Development and psychometric testing of the non-technical skills scale in medical and surgical hospital units for nursing students. *Nurse Education in Practice*, *67*, 103559. https://doi.org/10.1016/j.nepr.2023.103559

**Development and psychometric testing of the Non-Technical Skills Scale in medical and surgical hospital units for Nursing students**


## Abstract

Objective. To develop and validate a tool to assess the non-technical skills of medical and surgical hospital units undergraduate nursing students.

Background. In the area of healthcare, non-technical skills complement technical ones, and contribute to patient safety. High-fidelity simulation is an ideal resource for working on these skills. Thus, evaluation instruments are needed to understand the efficiency of this methodology. Although many evaluation instruments already exist, none measure non-technical skills of undergraduate nursing students in medical and surgical hospital units.

Design. An instrumental study design was employed.

Methods. Two-phases were used to develop and validate the scale: 1) Scale development. A group of experts defined the dimensions and components. Afterwards, the content was validated by experts, and a pilot study was conducted with undergraduate Nursing students. 2) Analysis of the psychometric properties of the scale. A total of 393 students were evaluated in high-fidelity simulation scenarios by three evaluators, through the use of the Non-Technical Skills in Medical and Surgical Hospital Units (NTS-Nursing) Scale.

Results. The content validity indexes were adequate for the total of the items and the total of the scale. The statistical descriptors of the items, the internal structure, and the reliability (internal consistency and inter-evaluator reliability) were analyzed, as well as the external evidence of validity, with adequate values obtained.

Conclusion. The NTS-Nursing scale is a valid and reliable instrument. Its structure of 10 items makes its use fast and easy.

**Keywords:** Nursing; Non-Technical Skills; Clinical Simulation; Psychometric; instrumental study.

## 1. Introduction.

The European Higher Education Area (EHEA) not only underlines the importance of providing nursing students with theoretical knowledge, but also asks for the development of technical and non-technical skills for their use when dealing with clinical problems (Adib-Hajbaghery & Sharifi, 2017; Flynn et al., 2017; Hong & Yu, 2017; Kaya et al., 2017; Nicksa et al., 2015). Non-technical skills (NTS) can be defined as "the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance" (Flin et al., 2013). Researchers have long recognized that the NTS and human factors are greatly important for safety in areas such as aviation, industry, and health (Flin et al., 2013; Murray et al., 2016; O'Connor et al., 2002; Patankar & Taylor, 2008; Pires et al., 2017).

NTS are necessary for the efficient performance in any profession, and their teaching in health sciences is challenging, as adequate evaluation and learning methodologies must be introduced (Leal Costa et al., 2014; Nicksa et al., 2015; Pires et al., 2017; Thomas, 2017).

Many studies have emphasized mistakes or negative incidents when caring for hospitalized patients, which have led to a great number of malpractice suits (Anderson & Abrahamson, 2017; Asensi-Vicente et al., 2018; Teal et al., 2019). Traditionally, nursing students are trained in environments where they obtain clinical knowledge and develop technical skills, while the non-technical skills are rarely promoted (Jepsen et al., 2015; Pires et al., 2017). Therefore, the mistakes in patient care are mainly related with

the lack of or insufficient non-technical skills (Asensi-Vicente et al., 2018; Irwin & Weidmann, 2015).

However, despite the high international commitment for reducing the number of adverse events and improving the standards of care (Liukka et al., 2020), at present, a coherent and systematic integration of NTS in nursing education is lacking (Pires et al., 2017). Traditionally, the nursing education curricula have combined the learning of theoretical knowledge with clinical training to develop the technical skills of students. However, these teaching method lack NTS training, and a definition and evaluation of what constitutes a safe and excellent nursing practice is also missing (Wunder, 2016).

Considering this situation, and given the constant development of new teaching methodologies, a case is made to provide nursing students with learning opportunities in different clinical contexts within a controlled environment (Papathanasiou et al., 2014). Clinical Simulation is a methodology used for learning technical and non-technical skills in a controlled and safe environment (Au et al., 2016; Flynn et al., 2017; Khalaila, 2014; Rudolph et al., 2014). These skills can be used in the future in uncommon, complex, or critical situations that may be found in a real clinical practice (Lewis et al., 2012).

## 2. Background

In the training of undergraduate nurses through high-fidelity simulation (HFS), the training of NTS is necessary to successfully deal with clinical practices in real-world environments. Therefore, it is essential for nursing students to not only develop technical skills, but non-technical ones as well (Pires et al., 2017).

The non-technical skills described in the literature on training of undergraduate and graduate nurses is varied (Jepsen et al., 2015; Pires et al., 2017). The main NTS in nursing, according to Flin et al., are management of tasks, teamwork, situation awareness, making of decisions, and communication (Flin et al., 2012, 2013). Table S1 defines these categories, and shows the most characteristic elements of each of them.

To efficiently provide NTS training, it is fundamental to rely on an instrument to measure these skills. In nursing, multiple tools have been developed to evaluate the NTS of undergrad and graduate students, although many of them are specific to specialized contexts (anesthesia, surgery room, emergencies, obstetrics, etc.) (Jepsen et al., 2015; Pires et al., 2017).

There is a great variety of evaluation tools that measure the NTS of different health professionals in different specialized contexts. However, an instrument does not exist which measures the NTS of undergraduate nursing students in medical and surgical hospital units. It is important for undergraduate nursing students to begin to acquire NTS in safe environments, and for this, the simulation of clinical scenarios of hospital units can help students develop clinical and non-technical skills, to successfully deal with their clinical practices and their future profession in real environments (Pires et al., 2017).

Therefore, the aim of the present study was to create and validate an evaluation tool to measure the non-technical skills in medical and surgical hospital units of undergraduate nursing students.

## 3. Method

### *3.1 Design*

An instrumental study was conducted to develop and validate a scale to measure the NTS of undergraduate nursing students in medical and surgical hospital units, which could be used by clinical simulation facilitators who are trained on the use of the scale.

The study was designed following the standards for educational and psychological evaluation tools (American Educational Research Association, American Psychological Association and National Council on Measurement in Education, 2018) and the standards for the evaluation of learning and performance in a clinical simulation from the International Nursing Association for Clinical Simulation and Learning (INACSL) (McMahon et al., 2021).

The study was performed in two phases: 1) scale development and 2) analysis of the psychometric properties of the scale (Figure 1).

-Insert Figure 1-

### *3.2 Phase 1: Scale development*

The objective was to define the dimensions and components of the scale. For this, a literature review was conducted, to select research studies on tools that evaluated NTS of health professionals, more specifically nurses, without a limit on the dates, and in the WOS and PubMed databases. The design of the questionnaire was based on the definition of non-technical skills in health sciences as "the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance" (Flin et al., 2013). They encompass a broad range of observable behavioral patterns which together shape the ability of nurses to provide safe and efficient care (Pires et al., 2017).

For the first version, the items were selected from scales that measured similar constructs, with the addition of new items related with non-technical skills specific to nurses in medical and surgical hospital units. Its design also considered the skills framework that is most utilized in the literature (Jepsen et al., 2015; Pires et al., 2017), and was analyzed and agreed-upon by the research team, composed of 3 experts in clinical simulation and nursing education with more than 10 years of experience. A map of skills was created, in which each item was associated with the most adequate dimension, prioritizing the non-technical skills that nursing students utilized in medical and surgical hospital units (Table 1).

The scale items were written in a manner that allowed the students to answer them with a 10-point Likert-type scale, from 1 = never, to 10 = always.

-Insert Table 1-

3.2.1. Content Validation by experts

A group of experts analyzed the dimensionality and the suitability of the items from the first version of the scale, using the Delphi method (Falzarano & Pinto Zipp, 2013). The group was composed by 10 experts with experience in clinical simulation, research, and nursing teaching with more than 10 years of experience. Each expert received the first version of the scale via email, along with a description of its objectives and dimensions. The experts evaluated the suitability of the items, their relevance to the dimension assigned, and their understandability, by answering a Likert scale of 4 points (1 = not at all relevant; 4 = very relevant). Also, they were asked to provide suggestions for improvements in the writing of the elements or other aspects when appropriate.

The content validity index (CVI) was calculated for each of the items and the total scale, with a value of > 0.80 considered adequate (Almanasreh et al., 2019).

#### 3.2.2. Pilot study with the scale

A pilot study was conducted with 18 students enrolled in the 3rd year of the Nursing Degree at the XXX, who were evaluated by three clinical simulation facilitators not familiar with the scale. The objective was to evaluate is understandability, acceptability, and time for completion of the scale for the evaluators.

### *3.3 Phase 2: Analysis of the psychometric properties of the scale*

#### 3.3.1. Participants

A non-probabilistic sampling method was used, and the target population were 3rd-year students enrolled in the Nursing Degree, who were taking the Clinical Practice 2 course at the University XXX, during the 2020-2021 and 2021-2022 academic years.

The inclusion criteria were the following: 1) 3rd-year Nursing Degree students, 2) Not missing any HFS session, 3) correctly answering all the questionnaires (sociodemographic variables and Communication Skills Scale, CSS), and 4) signing the informed consent form.

The students were evaluated by three evaluators who simultaneously carried out the evaluation of the NTS and the NIC interventions. The recommended sample size for validation studies is between 200 and 400 participants (Conway & Huffcutt, 2003).

### 3.3.2 Variables and Measurement Instrument

Different instruments were utilized to collect the variables of interest.

(a) sociodemographic variables: age, sex; (b) the version of the Non-Technical Skills in Medical and Surgical Hospital Units (NTS-Nursing) Scale from the 1st phase of the study; (c) To evaluate the nursing interventions, the Nursing Interventions Checklist (NIC) was utilized (Butcher et al., 2013), through the use of a Yes/No checklist, with the 5 most-important activities in NIC interventions to be evaluated in each simulated clinical scenario, which were selected by experts' consensus. Each activity performed by the students was scored with 2 points. Thus, in each intervention, a minimum of 0 and a maximum of 10 point could be obtained. (d) Communication Skills Scale (CSS), the version validated for health sciences students (Juliá-Sanchis et al., 2020) in Spain. The questionnaire was self-administered, and contained 18 items grouped into 4 dimensions: empathy, informative communication, respect, and social skills. These last two instruments were utilized to obtain external evidence of validity.

### 3.3.3 Procedure

During the 2020-2021 and 2021-2022 academic years, the students were evaluated through clinical scenarios conducted with a high-fidelity simulator, who acted as a patient in a hospital unit (medical or surgical), in a room which simulated a real hospital environment. The design of the simulation program took into account the standards from the International Nursing Association of Clinical and Simulation Learning (INACSL) (Watts et al., 2021). The simulated patient had intact cognitive skills. The scenarios were performed by groups of 2-3 students, and were recorded and watched in real time by the other students during the clinical simulation sessions.

Six clinical scenarios were designed, 4 based on internal medicine hospital units, and 2 based on surgical units (Table 2). All the scenarios were designed following the most-accepted recommendations for the design of scenarios in the international arena (Watts et al., 2021); and more specifically, the proposals by Moral and Maestre (Moral & Maestre, 2013), with the following stages: 1. Study of the training needs; 2. Definition of the learning objectives; 3. Agenda and planning of the scenario; and 4. Selection of the debriefing style.

-Insert Table 2-

Each simulation session was structured into prebriefing, briefing, simulation, and structured debriefing sessions. The students were evaluated by using the Non-Technical Skills in Medical and Surgical Hospital Unit (NTS-Nursing) Scale, and the Nursing Interventions Checklist (NIC) by an expert in clinical simulation, and two evaluators were trained on the use of the tool. The evaluators were trained in two training sessions in the use of the NTS-Nursing prior to the assessment. Students were individually assessed using video recordings of the simulated scenarios. At the end of the simulation-based training, the students completed the socio-demographic variables and the communication skills scale (CSS).

### 3.3.4 Data Analysis

A descriptive analysis of the items was performed (mean, standard deviation, asymmetry, and kurtosis). The discrimination of the items was calculated through a corrected item-dimension correlation (Carretero Dios & Pérez Meléndez, 2005).

Afterwards, an exploratory factorial analysis (EFA) and a confirmatory factorial analysis (CFA) were performed to analyze the degree in which the items of the scale shaped the

construct established. As recommended in many studies (Ferrando Piera & Anguiano Carrasco, 2010; Lloret-Segura et al., 2014; Schmitt, 2011), we considered the EFA and the CFA as opposite poles of the same continuum, that is, the EFA imposes minimum restrictions to obtain a final factorial solution in agreement with the theory presented, while the CFA imposes stronger restrictions that test the final factorial solution.

In the EFA, the method for the extraction of factors was the unweighted least squares (ULS) with PROMAX rotation (oblique rotation). The procedure utilized to determine the number of factors was the optimal implementation of the parallel analysis (Timmerman & Lorenzo-Seva, 2011). The matrix used to perform the analysis was a random half of the sample.

For the CFA, the weighted least square mean and variance (WLSMV) estimation method was used, utilized for categorically-organized data (Muthén & Muthén, 2010). The matrix used for this analysis was the entire sample. The assessment of fit of the data to the models was performed with $\chi 2/df$, the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSE). A good fit is considered when $\chi 2/df < 5$, CFI > 0.90, TLI > 0.90, and the RMSEA < 0.08 (Kline, 2015).

The reliability was calculated through the measurement of internal consistency (Cronbach's α) for each dimension of the scale, and the interobserver reliability of the scores of the items was evaluated with the intraclass correlation coefficient (ICC), interpreted according to Landis and Koch (Landis & Koch, 1977). The external validity was evaluated according to (a) the convergent validity obtained from Pearson's bivariate correlations between the scores from each dimension in the NTS-Nursing scale and the NIC interventions, and the Communication Skills Scale.

To analyze the data, the SPSS ® v.25 (Statistical Package for the Social Sciences), Mplus 7.0 (Muthén & Muthén, 2010) and FACTOR (Lorenzo-Seva & Ferrando, 2006) software packages were utilized. The statistical significance was set with a p-value of <0.05.

3.3.5 Ethical considerations

To conduct the study, approval from the Ethics Committee from the University of XXX (CEI) (Code 3762) was obtained. The confidentiality of the data and the anonymity of the participants were guaranteed, according to the current data protection laws. The study followed all the ethical principles from the Declaration of Helsinki (World Medical Association, 2013), and the participants signed an informed consent form which provided information on the object of the study.

## 4. Results

### *4.1 Phase 1: Scale development*

The initial version of the NTS-Nursing Scale© contained 10 items grouped into three dimensions (teamwork, management of the nursing interventions, and communication patient-family). The 10 experts reached an agreement on all the items after the 1st round of consultations. After considering their suggestions, slight modifications were made on 4 items. The content validity index was adequate for each of the items (CVI values between 0.9 and 1), as well as for the total scale (CVI = 0.9) (Table S2).

After the cognitive pilot study, it was verified that all the evaluators understood the writing and sense of the items. The questionnaire completion time was 10-15 minutes

(duration of the scenario), and the evaluation was made during the development of the simulated clinical scenario.

*4.2 Phase 2: Analysis of the psychometric properties of the scale*

4.2.1 Description of the participants

The final sample was composed by 393 students enrolled in the 3rd year of the nursing degree, who participated in the simulation-based learning (SBL) sessions, and who were evaluated by 3 evaluators trained on the use of the NTS-Nursing scale. The mean age was 21.05 (SD=2.9), and 81.4% (n=320) were women.

4.2.2 Item Analysis

The statistical description of the data showed high mean scores for all the items (between 7.58-7.95), with these scores having a normal distribution (asymmetry and kurtosis with values ranging from 1.5 to -1.5). The results of the discrimination indices through the item-total dimension corrected correlation were greater than .30 for all the items (Table S3).

4.2.3 Internal Structure of the Scale

The Kaiser–Meyer–Olkin (KMO) test of sampling adequacy was .88 (95% confidence interval of KMO = .862 - .907) and Bartlett's statistic 1553.0 ($p < .001$). An EFA was performed with the use of the unweighted least squares (ULS) with the PROMAX rotation method for the extraction of the factors, with various models tested to assess the overall fit. Finally, the model with the best fit was a three-factor model (Table 3).

In the EFA, all the items obtained factorial loads greater than 0.30 in the rotated matrix. According to the solution of this exploratory model, the factor "teamwork" was composed by items 1 to 4, the factor "management of the nursing interventions" was composed by items 5 to 8, and the factor "communication with the patient/family" was composed by items 9 and 10.

-Insert Table 3-

The final model of 4 oblique factors was tested with the 10 final items after the EFA. The fit indices of the CFA showed the following values: $\chi 2 = 68.93$ (df = 32; $p < .001$), CFI = .996, TLI = .995, and RMSEA = .05 (90% IC = .037−.072). The factorial loads oscillated between 1.003 and .803, as shown in the path diagram (Figure 2). As a function of these results, the fit of the data to the model was considered good.

-Insert Figure 2-

4.2.4 Reliability Analysis

The internal consistency (Cronbach's α) for each dimension of the scale was .874 for factor I (teamwork), .861 for factor II (management of the nursing interventions), and .967 for factor III (communication with the patient/family).

The ICC showed a high agreement between the scores of the scale completed by the three evaluators: factor I (teamwork) = .940 ($p<.001$) 95% CI (.929 - .950); factor II (management of the nursing interventions) = .984 ($p<.001$) 95% CI (.981 - .987); and factor III (communication with the patient/family) = .982 ($p<.001$) 95% CI (.979 - .985).

4.2.5 External evidence of validity

The bivariate correlations obtained between the dimensions found in the NTS-Nursing, the dimensions from the Communication Skills Scale, and the overall total in the NIC interventions, were positive and statistically significant ($p<.01$). These obtained high coefficients between 0.420 and 0.876, being greater in the dimensions that measured the same content (communication dimension from the NTS-Nursing, and the dimensions from the Communication Skills Scale) (Table 4).

-Insert Table 4-

## 5. Discussion

The NTS-Nursing scale is a 10-item scale that is fast and easy to administer, validated for undergraduate nursing students. It can be used by clinical simulation facilitators who are trained on its use, to evaluate the level of NTS in medical and surgical hospital units of the students, with respect to teamwork, management of nursing interventions, and communication with the patient/family. The high mean scores (1-10 range) indicate the high levels of each dimension and the overall scale.

The construction of the questionnaire was based on the definition of NTS skills in health sciences (Flin et al., 2013). The items were selected and written to closely mirror the most-utilized skills by nurses in medical and surgical hospital units. As far as we know, this is the first tool which describes NTS skills in this context (Jepsen et al., 2015; Pires et al., 2017).

In general, the NTS-Nursing scale addresses the same key NTS required from nurses in other, more specialized contexts (surgery, emergencies, etc.). These similarities are plausible, given the overlap of the nurses when providing care in different contexts. The

differences in the behavioral markers can indicate the roles, tasks, and competences of the nurses in more specialized contexts that differ in comparison with those developed in the medical and surgical hospital units.

If we focus on the scales that evaluate NTS in surgical teams (surgeons, anesthetists, instrumentalists), we observe that the NTS-Nursing scale evaluates the same behavioral markers than the most-utilized scales in these contexts, such as communication / interaction, vigilance, cooperation / team skills and leadership / managerial skills (Healey et al., 2004; Lyk-Jensen et al., 2014; Mishra et al., 2009; Mitchell et al., 2012; Sevdalis et al., 2008).

As for the scales that measure NTS in emergencies, resuscitation teams, and crisis situations, it was observed that the NTS-Nursing coincided with the behavioral markers used by other scales in this context, such as leadership, teamwork, task management, communication, and resource utilization (Cooper & Cant, 2014; Kim et al., 2006; Malec et al., 2007).

The main difference in the composition of the dimensions found in the NTS-Nursing scale, and the other scales utilized in more specialized contexts, was the number of dimensions. In the NTS-Nursing scale, the situational awareness and decision-making dimensions were not utilized, although they are normally utilized in more complex contexts (surgery room emergencies, etc.). However, these dimensions overlapped up to a certain point, with items included in the NTS-Nursing scale, as this scale evaluates aspects such as re-evaluation, a behavioral marker included in the Nurse Anesthetists' Non-Technical Skills (NANTS) scale, in the dimension decision making (Lyk-Jensen et al., 2014).

A concept developed in the last few years to emphasize the importance of the NTS in health sciences is the Crisis Resource Management (CRM) concept, which comes from the experience of commercial aviation in critical situations. Starting with the analysis of a series of aircraft accidents in the 1970's, it was understood that most of the errors in these types of situations were not the lack of technical training of the crew, but human factors of behavior, communication, and interaction between the team members (Howard et al., 1992). In 2017, a group of national and international experts in clinical simulations and CRM in anesthesia, emergencies, intensive care and pediatrics, developed the Emergency Crisis Resource Management (E-CRM) training model, through consensus based on the DELPHI method, which included: 1) the grouping of the CRM principle into 5 axes, to improve understanding and practicality; 2) recommendations of contextualization in the area of emergencies; and 3) a replicable multidisciplinary training strategy to promote its dissemination (Casal Angulo et al., 2020). The NTS-Nursing scale utilizes most of the 15 principles included in the 5 axes of the E-CRM.

The exploratory and confirmatory factorial analyses demonstrated the adequate fit of the model into three factors, and confirmed the internal structure of the three dimensions of the scale. This type of analysis is not usually included in the instruments used to measure NTS in nursing (Pires et al., 2017).

It was found that the inter-evaluator reliability (agreement of the scores of the scales completed by the three evaluators) was >.95, and that the internal consistency was acceptable, with a Cronbach's $\alpha$ >.85 for all the dimensions, considered adequate when the objective is diagnosis and classification (Carretero-Dios & Pérez, 2007). On the other hand, scales such as the Oxford NOTECHS System (Mishra et al., 2009) have shown little reliability in the teamwork and cooperation dimension. Most of the scales used in

nursing to evaluate the NTS in more specialized contexts have shown adequate interobserver reliabilities and internal consistencies (Pires et al., 2017).

External evidences of the validity of the scale were obtained, which showed positive and statistically significant correlations between the dimensions of the NTS-Nursing scale, the performance of the students in the nursing interventions, and the communication skills scale. The results are coherent with other studies, in which similar correlations were obtained in simulated (Peltonen et al., 2020; Riem et al., 2012; Sánchez Expósito et al., 2018) and real (Sánchez Expósito et al., 2019) contexts. Also, as expected, the dimension communication with the patient/family of the NTS-Nursing scale obtained greater correlation coefficients with the dimensions from the Communication Skills Scale.

The advantages of the NTS-Nursing scale over the existing scales include the improvement of the methodological weaknesses related with an inadequate description of the validation processes or the properties of the metrics or dimensions considered (Jepsen et al., 2015; Pires et al., 2017). The understandability, acceptability, and completion time of the scale shown makes its use easy with a single facilitator for the evaluation of the NTS of nursing students in medical and surgical hospital units.

### *5.1 Limitations*

There are some limitations that need to be considered. The participants were not selected randomly, and it used a cross-sectional design that only provides information about a specific point in time. Furthermore, the study was also restricted at the regional level. More research is needed to compare the NTS-Nursing scale with other objective tests, to examine its performance at the multi-center level, and to measure its sensitivity to changes after training based on clinical simulation in medical and surgical hospital units.

It would be interesting to determine the performance of the scale in different countries and with other health science students as well, to assess its adequacy in interprofessional simulations, for example, with nursing and medicine students.

## 6. Conclusion

The NTS-Nursing scale was created based on solid theoretical foundations, and was shown to have adequate metrics with respect to the analysis of the items, analysis of the internal structure, reliability, and evidence of validity. It allows the evaluation of the NTS of nursing students in medical and surgical hospital units, and provides information related with three dimensions: teamwork, management of nursing interventions, and communication with the patient/family.

## 7. References


Adib-Hajbaghery, M., & Sharifi, N. (2017). Effect of simulation training on the development of nurses and nursing students' critical thinking: A systematic literature review. *Nurse Education Today*, *50*, 17–24. https://doi.org/10.1016/j.nedt.2016.12.011

Almanasreh, E., Moles, R., & Chen, T. F. (2019). Evaluation of methods used for estimating content validity. *Research in Social & Administrative Pharmacy: RSAP*, *15*(2), 214–221. https://doi.org/10.1016/j.sapharm.2018.03.066

Anderson, J. G., & Abrahamson, K. (2017). Your Health Care May Kill You: Medical Errors. *Studies in Health Technology and Informatics*, *234*, 13–17.

Asensi-Vicente, J., Jiménez-Ruiz, I., & Vizcaya-Moreno, M. F. (2018). Medication Errors Involving Nursing Students: A Systematic Review. *Nurse Educator*, *43*(5), E1–E5. https://doi.org/10.1097/NNE.0000000000000481

Association American Educational Research, Association American Psychological and Education National Council on Measurement in Education. (2018). *Standards for Educational and Psychological Testing*. American Educational Research Association.

Au, M. L., Lo, M. S., Cheong, W., Wang, S. C., & Van, I. K. (2016). Nursing students' perception of high-fidelity simulation activity instead of clinical placement: A qualitative study. *Nurse Education Today*, *39*, 16–21. https://doi.org/10.1016/j.nedt.2016.01.015

Butcher, H. K., Bulechek, G. M., Dochterman, J. M., & Wagner, C. M. (2013). *Nursing Interventions Classification (NIC)—E-Book*. Elsevier Health Sciences.

Carretero Dios, H., & Pérez Meléndez, C. (2005). Normas para el desarrollo y revisión de estudios instrumentales. *International journal of clinical and health psychology*, *5*(3), 521–551.

Carretero-Dios, H., & Pérez, C. (2007). Standards for the development and review of instrumental studies: Considerations about test selection in psychological research. *International Journal of Clinical and Health Psychology*, *7*(3). http://www.redalyc.org/resumen.oa?id=33770319

Casal Angulo, C., Quintillá Martínez, J. M., & Espinosa Ramírez, S. (2020). Clinical simulations and safety in emergencies: Emergency Crisis Resource Management. *Emergencias: Revista De La Sociedad Espanola De Medicina De Emergencias*, *32*(2), 135–137.

Conway, J. M., & Huffcutt, A. I. (2003). A Review and Evaluation of Exploratory Factor Analysis Practices in Organizational Research. *Organizational Research Methods*, *6*(2), 147–168. https://doi.org/10.1177/1094428103251541

Cooper, S. J., & Cant, R. P. (2014). Measuring non-technical skills of medical emergency teams: An update on the validity and reliability of the Team Emergency Assessment Measure ( TEAM ). *Resuscitation*, *85*(1), 31–33. https://doi.org/10.1016/j.resuscitation.2013.08.276

Falzarano, M., & Pinto Zipp, G. (2013). Seeking consensus through the use of the Delphi technique in health sciences research. *Journal of Allied Health*, *42*(2), 99–105.

Ferrando Piera, P. J., & Anguiano Carrasco, C. (2010). El análisis factorial como técnica de investigación en psicología. *Papeles del psicólogo*, *31*(1), 18–33.

Flin, R., Glavin, R., Maran, N., & Patey, R. (2012). *Anaesthetists' Non-Technical Skills (ANTS) System Handbook* (University of Aberdeen).

Flin, R., O'Connor, P., & Crichton, M. (2013). *Safety at the Sharp End: A Guide to Non-Technical Skills*. CRC Press.

Flynn, F. M., Sandaker, K., & Ballangrud, R. (2017). Aiming for excellence—A simulation-based study on adapting and testing an instrument for developing non-technical skills in Norwegian student nurse anaesthetists. *Nurse Education in Practice*, *22*, 37–46. https://doi.org/10.1016/j.nepr.2016.11.008

Healey, A. N., Undre, S., & Vincent, C. A. (2004). Developing observational measures of performance in surgical teams. *BMJ Quality & Safety*, *13*(suppl 1), i33–i40. https://doi.org/10.1136/qshc.2004.009936

Hong, S., & Yu, P. (2017). Comparison of the effectiveness of two styles of case-based learning implemented in lectures for developing nursing students' critical thinking ability: A randomized controlled trial. *International Journal of Nursing Studies*, *68*, 16–24. https://doi.org/10.1016/j.ijnurstu.2016.12.008

Howard, S. K., Gaba, D. M., Fish, K. J., Yang, G., & Sarnquist, F. H. (1992). Anesthesia crisis resource management training: Teaching anesthesiologists to handle critical incidents. *Aviation, Space, and Environmental Medicine*, *63*(9), 763–770.

Irwin, A., & Weidmann, A. E. (2015). A mixed methods investigation into the use of non-technical skills by community and hospital pharmacists. *Research in Social and Administrative Pharmacy*, *11*(5), 675–685. https://doi.org/10.1016/j.sapharm.2014.11.006

Jepsen, R. M. H. G., Østergaard, D., & Dieckmann, P. (2015). Development of instruments for assessment of individuals' and teams' non-technical skills in healthcare: A critical review. *Cognition, Technology & Work*, *17*(1), 63–77. https://doi.org/10.1007/s10111-014-0306-y

Juliá-Sanchis, R., Cabañero-Martínez, M. J., Leal-Costa, C., Fernández-Alcántara, M., & Escribano, S. (2020). Psychometric Properties of the Health Professionals Communication Skills Scale in University Students of Health Sciences. *International Journal of Environmental Research and Public Health*, *17*(20), E7565. https://doi.org/10.3390/ijerph17207565

Kaya, H., Şenyuva, E., & Bodur, G. (2017). Developing critical thinking disposition and emotional intelligence of nursing students: A longitudinal research. *Nurse Education Today*, *48*, 72–77. https://doi.org/10.1016/j.nedt.2016.09.011

Khalaila, R. (2014). Simulation in nursing education: An evaluation of students' outcomes at their first clinical practice combined with simulations. *Nurse Education Today*, *34*(2), 252–258. https://doi.org/10.1016/j.nedt.2013.08.015

Kim, J., Neilipovitz, D., Cardinal, P., Chiu, M., & Clinch, J. (2006). A pilot study using high-fidelity simulation to formally evaluate performance in the resuscitation of critically ill patients: The University of Ottawa Critical Care Medicine, High-

Fidelity Simulation, and Crisis Resource Management I Study. *Critical Care Medicine*, *34*(8), 2167–2174. https://doi.org/10.1097/01.CCM.0000229877.45125.CC

Kline, R. B. (2015). *Principles and Practice of Structural Equation Modeling, Fourth Edition* (Fourth Edition). Guilford Publications.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174.

Leal Costa, C., Díaz Agea, J. L., Rojo Rojo, A., Juguera Rodríguez, L., & López Arroyo, M. J. (2014). Practicum y simulación clínica en el Grado de Enfermería, una experiencia de innovación docente. *REDU: Revista de Docencia Universitaria*, *12*(2), 421–451. https://doi.org/10.4995/redu.2014.5658

Lewis, R., Strachan, A., & Smith, M. M. (2012). Is High Fidelity Simulation the Most Effective Method for the Development of Non-Technical Skills in Nursing? A Review of the Current Evidence. *The Open Nursing Journal*, *6*(1). https://doi.org/10.2174/1874434601206010082

Liukka, M., Steven, A., Moreno, M. F. V., Sara-Aho, A. M., Khakurel, J., Pearson, P., Turunen, H., & Tella, S. (2020). Action after Adverse Events in Healthcare: An Integrative Literature Review. *International Journal of Environmental Research and Public Health*, *17*(13), E4717. https://doi.org/10.3390/ijerph17134717

Lloret-Segura, S., Ferreres-Traver, A., Hernández-Baeza, A., & Tomás-Marco, I. (2014). El Análisis Factorial Exploratorio de los Ítems: Una guía práctica, revisada y actualizada. *Anales de Psicología*, *30*(3), 1151–1169. https://doi.org/10.6018/analesps.30.3.199361

Lorenzo-Seva, U., & Ferrando, P. J. (2006). FACTOR: A computer program to fit the exploratory factor analysis model. *Behavior Research Methods*, *38*(1), 88–91. https://doi.org/10.3758/bf03192753

Lyk-Jensen, H. T., Jepsen, R. M. H. G., Spanager, L., Dieckmann, P., & Østergaard, D. (2014). Assessing Nurse Anaesthetists' Non-Technical Skills in the operating room. *Acta Anaesthesiologica Scandinavica*, *58*(7), 794–801. https://doi.org/10.1111/aas.12315

Malec, J. F., Torsher, L. C., Dunn, W. F., Wiegmann, D. A., Arnold, J. J., Brown, D. A., & Phatak, V. (2007). The Mayo High Performance Teamwork Scale: Reliability and Validity for Evaluating Key Crew Resource Management Skills. *Simulation in Healthcare*, *2*(1), 4–10. https://doi.org/10.1097/SIH.0b013e31802b68ee

McMahon, E., Jimenez, F. A., Lawrence, K., & Victor, J. (2021). Healthcare Simulation Standards of Best PracticeTM Evaluation of Learning and Performance. *Clinical Simulation In Nursing*, *58*, 54–56. https://doi.org/10.1016/j.ecns.2021.08.016

Mishra, A., Catchpole, K., & McCulloch, P. (2009). The Oxford NOTECHS System: Reliability and validity of a tool for measuring teamwork behaviour in the operating theatre. *BMJ Quality & Safety*, *18*(2), 104–108. https://doi.org/10.1136/qshc.2007.024760

Mitchell, L., Flin, R., Yule, S., Mitchell, J., Coutts, K., & Youngson, G. (2012). Evaluation of the Scrub Practitioners' List of Intraoperative Non-Technical Skills (SPLINTS) system. *International Journal of Nursing Studies*, *49*(2), 201–211. https://doi.org/10.1016/j.ijnurstu.2011.08.012

Moral, I. del, & Maestre, J. M. (2013). A view on the practical application of simulation in professional education. *Trends in Anaesthesia and Critical Care*, *3*(3), 146–151. https://doi.org/10.1016/j.tacc.2013.03.007

Murray, K., McKenzie, K., & Kelleher, M. (2016). The evaluation of a framework for measuring the non-technical ward round skills of final year nursing students: An observational study. *Nurse Education Today*, *45*, 87–90. https://doi.org/10.1016/j.nedt.2016.06.024

Muthén, L. K., & Muthén, B. O. (2010). *Mplus User's Guide.* (Sixth Edition). Muthén & Muthén.

Nicksa, G. A., Anderson, C., Fidler, R., & Stewart, L. (2015). Innovative approach using interprofessional simulation to educate surgical residents in technical and nontechnical skills in high-risk clinical scenarios. *JAMA Surgery*, *150*(3), 201–207. https://doi.org/10.1001/jamasurg.2014.2235

O'Connor, P., Flin, R., Fletcher, G., & Hemsley, P. (2002). Methods used to evaluate the effectiveness of CRM training: A survey of UK aviation operators. *Journal Of Human Factors And Aerospace Safety*, *2*(3), 235–256.

Papathanasiou, I. V., Tsaras, K., & Sarafis, P. (2014). Views and perceptions of nursing students on their clinical learning environment: Teaching and learning. *Nurse Education Today*, *34*(1), 57–60. https://doi.org/10.1016/j.nedt.2013.02.007

Patankar, M. S., & Taylor, J. C. (2008). MRM Training, Evaluation, and Safety Management. *The International Journal of Aviation Psychology*, *18*(1), 61–71. https://doi.org/10.1080/10508410701749449

Peltonen, V., Peltonen, L.-M., Salanterä, S., Hoppu, S., Elomaa, J., Pappila, T., Hevonoja, E., Hurme, S., Perkonoja, K., Elomaa, T., & Tommila, M. (2020). An observational study of technical and non-technical skills in advanced life support in the clinical setting. *Resuscitation*, *153*, 162–168. https://doi.org/10.1016/j.resuscitation.2020.06.010

Pires, S., Monteiro, S., Pereira, A., Chaló, D., Melo, E., & Rodrigues, A. (2017). Non-technical skills assessment for prelicensure nursing students: An integrative review. *Nurse Education Today*, *58*, 19–24. https://doi.org/10.1016/j.nedt.2017.07.015

Riem, N., Boet, S., Bould, M. D., Tavares, W., & Naik, V. N. (2012). Do technical skills correlate with non-technical skills in crisis resource management: A simulation study. *British Journal of Anaesthesia*, *109*(5), 723–728. https://doi.org/10.1093/bja/aes256

Rudolph, J. W., Raemer, D. B., & Simon, R. (2014). Establishing a Safe Container for Learning in Simulation: The Role of the Presimulation Briefing. *Simulation in Healthcare*, *9*(6), 339–349. https://doi.org/10.1097/SIH.0000000000000047

Sánchez Expósito, J., Jiménez-Rodríguez, D., Díaz Agea, J. L., Carrillo Izquierdo, M. D., & Leal Costa, C. (2019). Impact of Socio-Emotional Skills On The Performance of Clinical Nursing Practices. *International Journal of Nursing Education Scholarship*, *16*(1). https://doi.org/10.1515/ijnes-2019-0064

Sánchez Expósito, J., Leal Costa, C., Díaz Agea, J. L., Carrillo Izquierdo, M. D., & Jiménez Rodríguez, D. (2018). Socio-emotional competencies as predictors of performance of nursing students in simulated clinical practice. *Nurse Education in Practice*, *32*, 122–128. https://doi.org/10.1016/j.nepr.2018.07.009

Schmitt, T. A. (2011). Current Methodological Considerations in Exploratory and Confirmatory Factor Analysis. *Journal of Psychoeducational Assessment*, *29*(4), 304–321. https://doi.org/10.1177/0734282911406653

Sevdalis, N., Davis, R., Koutantji, M., Undre, S., Darzi, A., & Vincent, C. A. (2008). Reliability of a revised NOTECHS scale for use in surgical teams. *The American*

*Journal of Surgery*, *196*(2), 184–190. https://doi.org/10.1016/j.amjsurg.2007.08.070

Teal, T., Emory, J., & Patton, S. (2019). Analysis of Medication Errors and near Misses Made by Nursing Students. *International Journal of Nursing Education Scholarship*, *16*(1). https://doi.org/10.1515/ijnes-2019-0057

Thomas, M. J. W. (2017). *Training and Assessing Non-Technical Skills: A Practical Guide*. CRC Press.

Timmerman, M. E., & Lorenzo-Seva, U. (2011). Dimensionality assessment of ordered polytomous items with parallel analysis. *Psychological Methods, 16*(2), 209–220. https://doi.org/10.1037/a0023353

Watts, P. I., McDermott, D. S., Alinier, G., Charnetski, M., Ludlow, J., Horsley, E., Meakim, C., & Nawathe, P. A. (2021). Healthcare Simulation Standards of Best PracticeTM Simulation Design. *Clinical Simulation In Nursing*, *58*, 14–21. https://doi.org/10.1016/j.ecns.2021.08.009

World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA*, *310*(20), 2191–2194. https://doi.org/10.1001/jama.2013.281053

Wunder, L. L. (2016). Effect of a nontechnical skills intervention on first-year student registered nurse anesthetists' skills during crisis simulation. *AANA Journal*, *84*(1), 46–51. Scopus.

**Funding information**: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Conflict of interest**: None

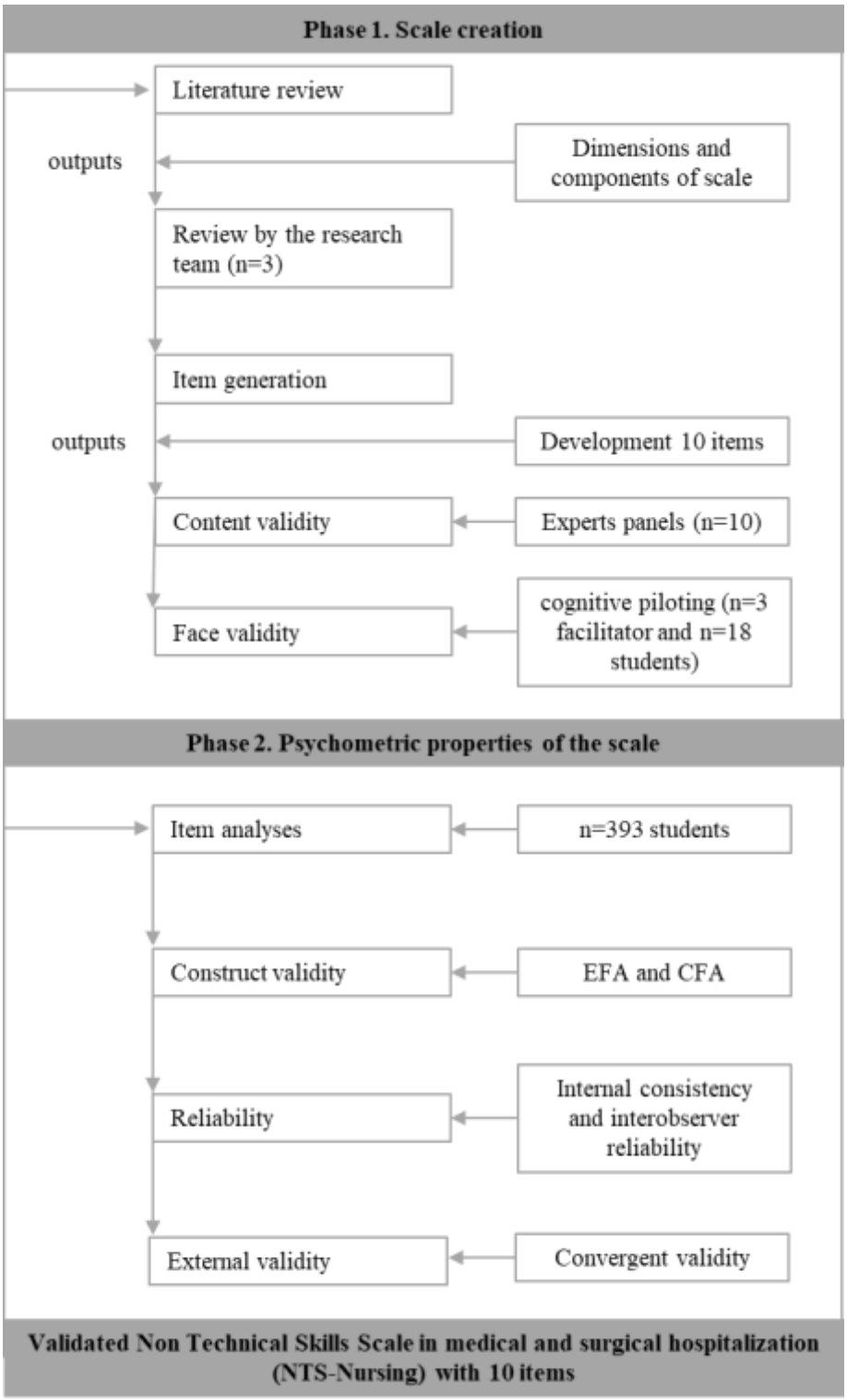
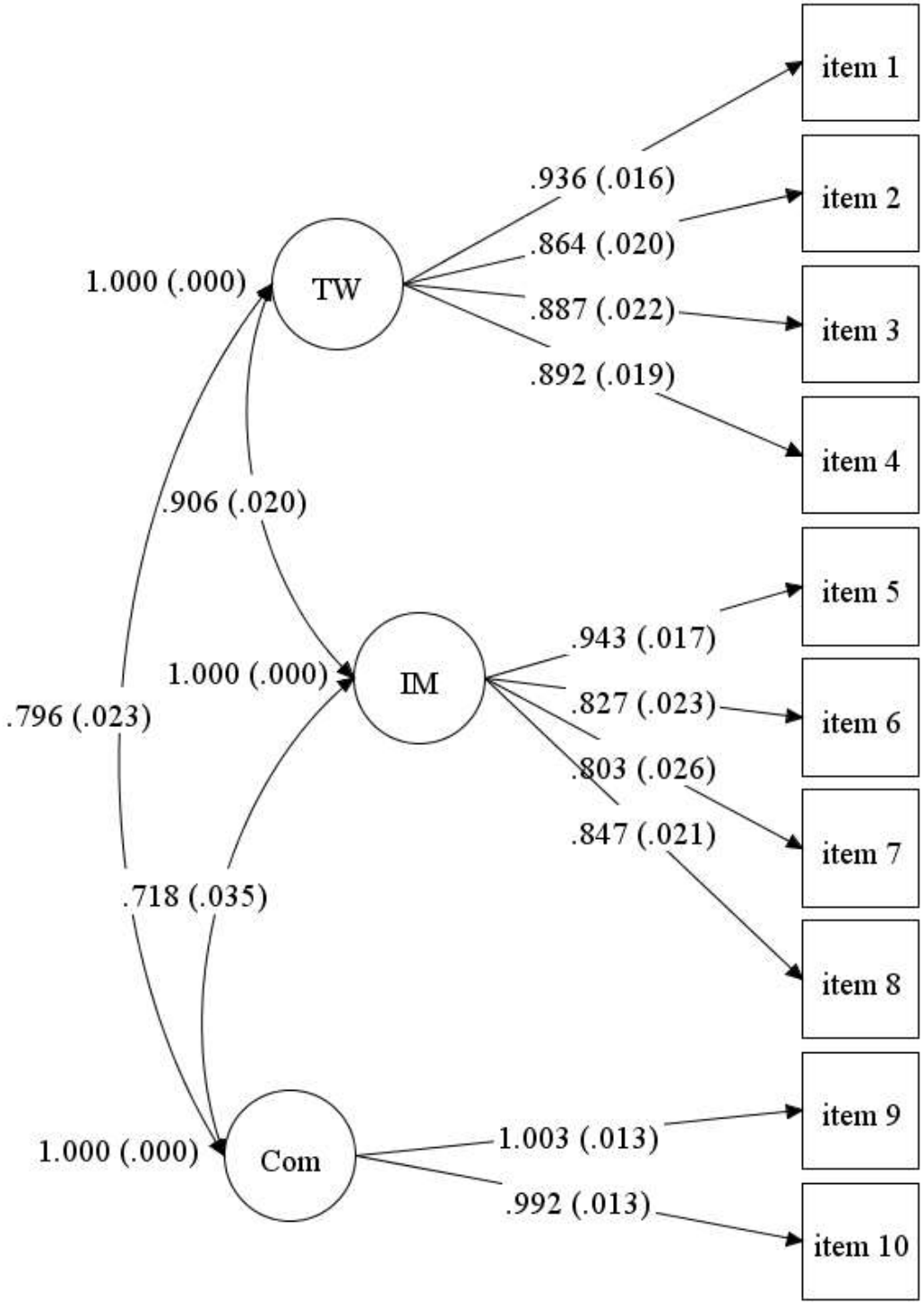



Figure 1. Summary of the process employed for the development and validation of the NTS-Nursing Scale.




TW: Team work; IM: Intervention management; Com: patient/family communication

Figure 2. Confirmatory factorial analysis of the three oblique factors model with the standardized estimation of the parameters.

Table S1. Categories and elements of non-technical skills in Nursing.

| **Category** | **Definition** | **Elements** |
|---|---|---|
| Task Management (Flin et al., 2012) | Skills for organizing resources and required activities to achieve goals, be they individual case plans or longer-term scheduling issues. | - Planning and preparing.<br>- Prioritizing.<br>- Providing and maintaining standards.<br>- Identifying and utilizing resources. |
| Team Working (Flin et al., 2012, 2013) | Skills for working in a group context, in any role, to ensure effective joint task completion and team member satisfaction; the focus is particularly on the team rather than the task. | - Coordinate activities.<br>- Leadership.<br>- Exchange information.<br>- Support others. |
| Situation Awareness (Flin et al., 2013) | The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future. | - Gathering information.<br>- Interpreting information.<br>- Anticipating future states. |
| Decision Making (Flin et al., 2012, 2013) | Skills for reaching a judgement to select a course of action or make a diagnosis about a situation, in both normal conditions and in time-pressure crisis situations. | - Situation assessment (definition problem).<br>- Generating and considering one or more response options,<br>- Selecting and implementing an option.<br>- Re-evaluating. |
| Communication (Flin et al., 2013) | Communication is a major part of good teamwork and is fundamental to workplace efficiency and safety. Communication is the exchange of information, feedback or response, ideas and feelings. It provides knowledge, institutes relationships, establishes predictable behavior patterns, maintains attention to the task, and is a management tool. | - Send information clearly and concisely.<br>- Include context and intent during information exchange.<br>- Receive information, especially by listening.<br>- Identify and address barriers to communication. |

Table S2. Calculation of the CVI of the NTS-Nursing scale with the evaluations from 10 experts.

| Item | Expert 1 | Expert 2 | Expert 3 | Expert 4 | Expert 5 | Expert 6 | Expert 7 | Expert 8 | Expert 9 | Expert 10 | CVI Item | Number of agreements (3-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 10 |
| 2 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 1 | 10 |
| 3 | 3 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 2 | 0.9 | 9 |
| 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 1 | 10 |
| 5 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 3 | 3 | 4 | 1 | 10 |
| 6 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 10 |
| 7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 10 |
| 8 | 3 | 4 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 0.9 | 10 |
| 9 | 4 | 3 | 3 | 3 | 3 | 4 | 2 | 3 | 3 | 4 | 0.9 | 9 |
| 10 | 3 | 4 | 3 | 2 | 3 | 3 | 3 | 3 | 4 | 3 | 0.9 | 9 |
| | | | | | | | | | | **CVI TOTAL** | 0.9 | |

Table S3. Descriptive statistics and correlations item-total dimensions of the scale.

| Item | *M* | *SD* | Asymmetry | Kurtosis | Correlation item-total dimension |
|---|---|---|---|---|---|
| 1. The members of the team coordinate themselves to perform nursing interventions. | 7.89 | 0.63 | -0.50 | 0.93 | 0.76 |
| 2. A member of the group lead the team and/or task, adapts to the rest of the team or situation. | 7.58 | 0.77 | -0.12 | 0.18 | 0.72 |
| 3. Give and receive information and data necessary for the coordination of the team and the finishing of nursing interventions. | 7.95 | 0.65 | -0.50 | 0.87 | 0.75 |
| 4. The members of the team help each other to perform the nursing interventions. | 7.87 | 0.62 | -0.41 | 0.73 | 0.70 |
| 5. Prepare the material needed beforehand for performing the nursing interventions, they use them to achieve the objectives, minimizing interruptions, and they adapt to the changes in the patient. | 7.76 | 0.74 | -0.29 | -0.08 | 0.72 |
| 6. Plan the activities of the nursing intervention according to importance (for example, severity, time, etc.). | 7.60 | 0.79 | -0.03 | -0.44 | 0.75 |
| 7. Meet with the basic good-practices principles (checklist, protocols, etc.) for the performing of nursing interventions.. | 7.63 | 0.70 | -0.35 | 0.01 | 0.65 |
| 8. Continuously review the situation of the patient and re-evaluate the situation after performing the nursing interventions. | 7.60 | 0.85 | -0.48 | 1.42 | 0.73 |
| 9. Provide information in a clear and understandable manner for the patient and/or family. | 7.65 | 0.74 | -0.11 | -0.28 | 0.94 |
| 10. Explore the feelings and emotions of the patient and/ or family. | 7.64 | 0.75 | 0.05 | -0.41 | 0.94 |

*M*: Mean; *SD*: Standard deviation

Table 2. Scenarios in which students learned through clinical simulation.

| Simulated Clinical Scenario | NIC Interventions |
|---|---|
| Patient diagnosed with Pneumonia. Admitted from emergencies due to dyspnea, increase in expectoration and fever (38.5 ºC). Patient states that he has trouble breathing. | - Vital signs monitoring (6680)<br>- Medication administration (2300)<br>- Oxygen therapy (3320)<br>- Phlebotomy: arterial blood sample (4232) |
| Patient admitted in Cardiology due to an Acute Coronary Syndrome without ST elevation (NSTEACS). He is admitted to the ward, waiting for the coronary angiography study. The family alerts that the patient has thoracic pain and nausea at rest. | - Cardiac care: acute (4044)<br>- Vital signs monitoring (6680)<br>- Phlebotomy: venous blood sample (4238) |
| Patient admitted in the cardiology unit due to an acute coronary syndrome without ST (10 days ago he was admitted to the ICU, and two stents were placed on the right coronary after a therapeutic catheterization). He may be discharged tomorrow. His wife accompanies him, who alerts us that her husband is not responding. | - Resuscitation (6320)<br>- Defibrillator Management: External (4095)<br>- Medication Administration: Intravenous (IV) (2314) |
| Patient admitted to the Internal Medicine unit due to a decompensation of his Type I diabetes due to endocrinology (five days ago, he had a diabetic ketoacidosis that was treated in the ICU where he was admitted). He has high blood pressure. His daughter accompanies him, who alerts us that his father believes he is suffering from hyperglycemia. | - Hyperglycemia Management (2120)<br>- Liquids / electrolytes management (2080)<br>- Medication Administration: Intravenous (IV) (2314) |
| Patient diagnosed with acute pancreatitis with choledocholithiasis. After the surgery (cholecystectomy), the patient has a left Penrose drain in the pouch of Douglas, and a Jackson-Pratt drain in pancreas cells. The patient is in a lot of pain and nausea. | - Nausea management (1450)<br>- Pain management (1400)<br>- Tube care (1870) |
| The patient is the third on the surgery list of traumatology, and she will be given prosthetic hip after an accidental fall. She feels disheartened and insecure, she is afraid, and is stressed about her hygiene, she doubts she will be able to walk again. Before going to the surgery room, we need to give her concentrated red blood cells, as the analytical test in emergencies indicated low hematocrits and red blood cell values. | - Teaching: preoperative (5610).<br>- Surgical preparation (2930).<br>- Blood products administration(4030) |

Table 3. Goodness-of-Fit indices of the 1 factor, 2 factors, and 3 factor models with PROMAX rotation.

| **Models** | $\chi^2$ | **gl** | **p** | **RMSEA (IC 95%)** | **TLI** | **CFI** |
|---|---|---|---|---|---|---|
| 1 factor | 2984.1 | 45 | .000 | 0.154 (0.107 – 0.183) | 0.926 | 0.943 |
| 2 factors | 57.91 | 26 | .000 | 0.078 (0.025 – 0.107) | 0.981 | 0.989 |
| 3 factors | 26.13 | 18 | .100 | 0.047 (0.009 – 0.068) | 0.993 | 0.997 |

Table 4. Bivariate correlations between the dimensions of the NTS-Nursing scale, the dimensions from the Communication Skills Scale, and the total score in the NIC nursing interventions.

| | TW | MI | Com |
|---|---|---|---|
| IC | .641** | .591** | .810** |
| Emp | .709** | .631** | .876** |
| Resp | .664** | .624** | .826** |
| Assert | .512** | .420** | .678** |
| Total NIC | .705** | .644** | .516** |

**. The correlation is significant at 0.01
NTS dimensions: TW: Team work; MI: Management of the Nursing Interventions; Com: Communication with the patient/family. CSS dimensions: IC: Informational Communication; Emp: Empathy, Resp: Respect; Assert: Assertiveness.