ARTICLE





# Impact of simulation-based learning on family caregivers during the rehabilitation period of individuals with spinal cord injury

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#### Abstract

Study design Mixed-methods study.

**Objective** Evaluate the knowledge that family caregivers of individuals with spinal cord injuries acquired through the use of a high-fidelity simulation-based learning (SBL) program.

**Setting** The study was comprised of three phases: a previous qualitative research study detecting training needs, one in which clinical simulation scenarios were designed, and a final quasi-experimental phase in which ten caregivers of individuals with spinal cord injuries were trained in their care using simulations at the Toledo National Hospital for Paraplegics (Spain).

**Methods** The competences acquired by the family were evaluated before and after the simulation training. A researcher-validated tool for each scenario was utilized for this evaluation.

**Results** Four learning scenarios were designed based on the needs identified through the caregiver interviews. Following the training of the caregivers with SBL, an increase in their knowledge and skills was identified. For all the scenarios, the caregivers obtained a higher average score on the post test than on the pre test, and these differences were significant (p < 0.001).

**Conclusions** Simulation training is a useful and efficient learning tool for caregivers of individuals with a spinal cord injury.

### Introduction

Spinal cord injuries (SCI) create new needs and priorities in the lives of people who suffer from it and their loved ones as well. [1, 2]. A person with a SCI is often dependent on family members for physical care, social contact, and emotional and financial support. Thus, his or her recovery rests heavily on family support, especially during the early phase of the recovery period immediately following the injury [3]. As the caring for people with a SCI has specific

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idiosyncrasies that differentiate it from the caring of patients with other types of neurological injuries [4], it is important that family caregivers are adequately trained.

Currently, one of the main challenges is to improve the role of the family caregiver, as there have been negative reports in the scientific literature regarding the support that caregivers of people with SCI receive [5]. Some studies [6, 7] have highlighted the importance of providing information and training to quell the fears and uncertainties of the caregivers. Such efforts allow caregivers to become more comfortable and to embrace the increased responsibility with the necessary conscientiousness and engagement. When caregivers are introduced to and involved in the rehabilitation process from an early stage, they can become more prepared for dealing with the needs of the injured relative and are able to face the challenges that arise once the patient is discharged and returns home [8].

As previously shown, high-fidelity clinical simulation, as a methodology, has been utilized as a learning and training option for relatives and patients [9, 10]. Simulation-based learning (SBL) fosters the acquisition of many types of

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practical skills [11], and health professionals trained with this methodology have shown an increase in knowledge, skills, and behaviors, although the effects on patients have been more modest [12]. For this methodology to be effective, the participants must learn from experience and must analyze their strengths and weaknesses, and the observations made by the instructors during the simulation must be taken in to account as well. Their interactions can result in constructive feedback, which is the core of the learning process [13–15].

SBL is used in the professional development of many health science professional groups because it promotes training in technical and nontechnical skills and allows exercises to be repeated as many times as necessary [11]. In addition, the simulation shortens the time needed to learn these skills [16, 17]. Until now, no previous studies have been identified where SBL was used by family caregivers of people with SCI to acquire care skills. Numerous studies [18–22] have highlighted the importance of education programs and other efforts to increase the skills of those who provide daily care for their relatives. However, because of the specificity of SCI, few studies have investigated the best method to teach care procedures to family members or caregivers of people with SCI. A research study on training caregivers of SCI patients [23] examined training with online videos. In this study, people with SCI and their caregivers felt they had gained better information in a more comfortable way via videos than via training manuals and conventional tutorials. Likewise, in another study of caregivers of people with a chronic disease [24], training videos were perceived as more valuable sources of support than traditional forms of information delivery, as the images and sound allowed the participants to recognize aspects of their own daily lives and because the videos allowed the participants to control the pace of their learning.

We posited and tested the hypothesis that patients with SCI and their caregivers could benefit from this new learning methodology during the rehabilitation period. Therefore, the objective of this work was to evaluate the knowledge, skills, and attitudes acquired by caregivers of people with SCI after using clinical simulation.

## Methods

This study included three phases. Phase 0. Qualitative research. Detection of training needs of family caregivers of people with SCI. Phase 1. Design of simulation scenarios for the training of family caregivers. Phase 2. Quasi-experimental study. Evaluation of the acquisition of skills of the caregivers with simulated scenarios.

#### Phase 0. Qualitative research

This research is a pilot study based on a previous qualitative research [25], considered here as the first step or Phase 0, in which the needs of the family caregivers were determined. An exploratory qualitative study was performed using semi-structured interviews with open-ended questions designed to determine the caregivers' level of training and the information they possessed. Once all interviews were recorded, they were transcribed and assigned an alphanumeric code. All of the interviews were then processed using MAXQDA-12<sup>®</sup> coding and qualitative analysis software, and the data were analyzed following Colaizzi's model [26].

In this phase, the sample was comprised of primary caregivers of people with SCI and health professionals specializing in SCI. These caregiver-professional models were used to determine the gaps and needs in caregiver's information and training during the early phases of caring for people with SCI. The final sample consisted of 25 volunteers (16 caregivers and 7 health professionals who were experts in SCI).

The study results that focused on the specific skills required to care for a person with SCI are presented in this study. The remaining qualitative results regarding the needs, training/information sources, and the new roles embraced by the relatives have already been presented in a previous research article [25].

The subsequent phases (Phases 1 and 2) are discussed in the present work. In the first phase, clinical simulations were designed; and in the second (quasi-experimental) phase, the family caregivers underwent training based on SBL techniques. These phases are described below.

#### Phase 1. Design of simulation scenarios

When designing the simulation scenarios, we followed the recommendations from Maestre et al. [27], and the following stages were carried out: (1) evaluation of the training needs. This phase was planned based on the interviews of caregivers conducted during a pilot study [25] and an indepth review of the literature. (2) Definition of the specific learning objectives. (3) Schedule and planning of the scenarios. (4) Debriefing. (5) Design of the scenarios according to the learning skills and goals that were initially defined.

# Phase 2. SBL program and evaluation of the acquired skills

A quasi-experimental study was performed that was comprised of an SBL-based skills and caregiving training program that took into account the patient's level of injury and the learning needs of the family caregiver. This training was performed at the National Hospital for Paraplegics (NHP), a

Table 1	Sociodemographic	data of th	e participants
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Family caregivers					Person with SCI
Code	Gender	Socioeconomic status	Previous caregiving experience	Gender	Injury level*
Wife of individual injured 7 months ago	F	Medium	No	М	C6 complete
Mother of individual injured 12 months ago	F	Medium-high	No	М	C4 incomplete
Wife of individual injured 11 months ago	F	Medium	No	М	T2 complete
Mother of individual injured 4 months ago	F	Medium	No	М	T7 complete
Wife of individual injured 9 months ago	F	Medium	No	М	C5 incomplete
Wife of individual injured 6 months ago	F	Medium	No	М	C7 complete
Daughter of individual injured 3 months ago	F	Medium	No	F	T10 complete
Daughter of individual injured 2 months ago	F	Medium	No	М	C7 incomplete
Wife of individual injured 2 months ago	F	Medium-low	No	М	C7 incomplete
Wife of individual injured 12 months ago	F	Medium	No	М	C6 complete

\*Injury level refers to neurological level as defined by the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI)

Spanish reference center for SCI patients, during the months of June and July 2015.

The clinical simulation training used the high-fidelity life-size simulator model Sim Man 3G® (Laerdal Medical, Ltd., Orpington, UK). An expert instructor with over 3 years of experience in clinical simulation was in charge of the session. A computer application controlled the vital signs of the model, which could be checked on a multiparametric monitor placed next to the patient's bed. Because the caregivers were not health professionals, the level of interpretation and the complexity of the information shown on the monitor were basic, including parameters such as oxygen saturation, heart rate, and respiratory frequency, depending on the scenario. The scenarios were four: upper airway care, neurogenic bladder care, neurogenic bowel care, and mobilization and pressure-induced ulcer (PIU) prevention and treatment. These scenarios were all conducted with the mannequin, except for mobilization and PIU, which was conducted with a live actor for more realism.

During the study period, the NHP provided several contiguous rooms to use as a simulation room, a debriefing room, and a space to install the control center and the instructor's area. The simulation room was furnished with the furniture and equipment normally found in NHP's rooms, thus recreating all of the details to make the simulation as realistic as possible.

Before performing a scenario, each caregiver was instructed on the simulation parameters and debriefing techniques and presented with an introduction of how each clinical scenario would unfold. The mean duration of each scenario was 10 min, and the debriefings took 40 min.

All scenarios were performed twice by each caregiver, once before and once after the clinical simulation training. The caregivers' performances were recorded using two video cameras (one facing the patient and the other placed obliquely). To ensure an objective evaluation, the videos were assigned random numbers. The videos were then evaluated by four experts other than those who designed the scenarios and the experiments. The experts were chosen by having a minimum of 3 years of experience in the teaching of patient care through clinical simulation in a university setting. Two of the experts were also members of the staff at the NHP, with extensive experience in the area of care of patients with SCI.

These experts evaluated the acquisition of the skills by the caregivers without knowing whether the video they were watching was the initial or final performance. Before the evaluation, in order to ensure that the evaluations were consistent, the experts were instructed on how to use the evaluation tool.

To select the participants, a nonprobability sampling criterion was used; professionals from the NHP helped by facilitating contact with potential participants. The sample used in this study was comprised of a total of ten caregivers (Table 1). Their inclusion was determined by their relatives' SCI level and the associated care they required. For example, in order to work on care of the upper airway, it was necessary to include family members of people with an upper medullary or cervical lesion, who would have had a tracheostomy performed on them.

The experts consensually designed four ad hoc evaluation templates for each of the scenarios (see Supplementary File). Each list organized the learning skills according to the different interventions and evaluated the skills using a Likert scale with five response options, with one being not acquired, and five being completely acquired. For some interventions that could not be evaluated continuously (i.e., those in which the caregiver could or could not perform the skills), the Likert scale was replaced with a dichotomous (yes/no) response. The experts' evaluations were entered into a Microsoft Excel<sup>®</sup> spreadsheet and a database was constructed with the program SPSS<sup>®</sup> v21 (Statistical Package for the Social Sciences, IBM Corp. Released 2012) to process the data. Different statistical tests were employed to analyze the data: descriptive statistics (average and standard deviation) were obtained for the quantitative variables and the frequencies, and percentages were obtained for the categorical variables.

As most of the outcome measurements did not have a normal distribution, data for before and after all the interventions were subjected to bootstrap analysis [28] and were presented as mean and 95% CI. Statistical significance was assessed with Student's t test with a Bonferroni correction for multiple comparisons.

Also, the size effect was calculated with Cohen's d in order to evaluate the magnitude of the effect of the intervention, using values proposed by Ferguson [29], where 0.41 indicated a small effect, 1.15 a medium effect, and 2.70 a large effect.

To estimate the reliability of the evaluation templates, the interobserver agreement test was applied by calculating the intraclass correlation coefficient (ICC) [30, 31]. Its value was interpreted as the percentage of the score variability that depended solely on the variability among the subjects tested.

# Results

#### Phase 0

The training needs identified as emergent from the caregiver's interviews are shown in Table 2. The information identified during the qualitative study concurred with some of the more important complications described in the bibliography with respect to the care of people with SCI.

#### Phase 1

A list was compiled of all the items considered for the SBL scenarios, including the skills expected to be acquired.

- Evaluation of the training needs. The study revealed several specific issues related to learning needs that could be adequately addressed with SBL. The identified areas of knowledge were: handling of the neurogenic bladder and the neurogenic bowel, preventing urinary infections, preventing and treating PIUs, knowing about and detecting the most common complications that may occur (autonomic dysreflexia, spasticity, and respiratory infections), managing the upper airway, and aspirating secretions.
- 2. Definition of the specific learning objectives. The

Table 2 Learning needs detected during the research that could be addressed with SBL

Neurogenic bladder	Upper airway
<ul> <li>Caring for urinary catheterization.</li> <li>Identifying dysreflexic crisis.</li> <li>Addressing urinary retention.</li> <li>Placing the urological bag.</li> <li>Caring for the urological field (infections).</li> <li>Providing intermittent urinary catheterization.</li> </ul>	<ul> <li>Learning how to react to oxygen desaturation.</li> <li>Assessing pulse oximetry.</li> <li>Managing the airway management trainer.</li> <li>Operating the respirator.</li> <li>Performing respiratory physiotherapy.</li> <li>Practicing working with the tracheostomy.</li> <li>Aspirating secretions.</li> <li>Developing a respiratory approach.</li> <li>Caring for the respiratory field, i.e., knowing what to do when thick and abundant secretions appear.</li> <li>Changing the tracheostomy tube.</li> <li>Using the aspirator for secretions</li> </ul>
Neurogenic bowel	<b>Mobilizations and PIUs</b>
<ul> <li>Following the constipation protocol.</li> <li>Providing hydration.</li> <li>Following the defecation protocol, laxatives, manual removal, and enema application.</li> <li>Assisting with intestinal evacuation.</li> <li>Identifying fecal impaction crisis.</li> </ul>	<ul> <li>Dressing the patient.</li> <li>Transferring the patient.</li> <li>Preventing PIUs.</li> <li>Exercising the patient's limbs.</li> <li>Learning how to move and seat the patient.</li> <li>Mobilizing the patient.</li> <li>Understanding the protocol for mobilizing patients.</li> <li>Providing routine skin surveillance.</li> <li>Working with the respirator, the harness, the lift, and the chair.</li> <li>Assisting with postural changes.</li> <li>Coring for the patient's ching</li> </ul>

objectives were selected according to the needs of the caregivers, as previously specified in the scientific literature. These needs were dependent on the type of lesion of the patient and the care corresponding to the level of the lesion.

- 3. Schedule and planning of scenarios. Once the objectives were established, the specific learning interventions for each skill were selected, the number of required hours was estimated, and a schedule was created so that the caregiver could accomplish the established objectives.
- 4. Debriefing. The main issues to be discussed following the simulation were defined. The participant's behaviors were analyzed, and the main learning objectives were reflected upon and discussed.
- 5. Design of the scenarios according to the learning skills and goals that were initially defined.

The simulation scenarios (Tables 3 and 4) were designed by taking into account the main need areas identified during the interviews with the informants that were conducted prior

	Table 3	Skills	and	actions	for	each	of	the	scenario
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Skills	Actions
Neurogenic bowel scenario	
The caregiver is able to identify the signs of constipation in the patient.	Shows the knowledge required to detect signs of constipation.
The caregiver knows how to administer enemas.	Prepares the material for evacuation via rectal probing. Positions the rectal probe. Administers enema. Performs digital rectal examination to check the rectal ampulla.
The caregiver is aware of the complication of autonomic dysreflexia caused by fecal impaction, identifies the symptoms, and learns to rule out the triggering factors of a dysreflexia crisis.	Identifies the symptomatology of a dysreflexia crisis. Determines the triggering causes of a dysreflexia crisis.
Mobilization of patients and prevention of PIUs scenario	
The caregiver knows what a PIU is.	Explains what a PIU is.
The caregiver learns to perform the postural changes.	Performs the postural changes.
The caregiver is able to operate the crane to lift and move the patient.	Operates the crane for mobilizations.
The caregiver identifies the triggering factors for PIUs.	Verbally describes all measures put in place to prevent PIUs.
Neurogenic bladder scenario	
The caregiver learns to detect signs and symptoms of a urinary tract infection.	Detects signs and symptoms associated with a urinary infection.
The caregiver knows the adequate pattern of bladder fluid intake (depending on whether the probe is permanent or intermittent).	Indicates the correct pattern of fluid intake.
The caregiver prepares all the required material for the intermittent catheterization.	Prepares the material for a bladder evacuation by intermittent catheterization.
The caregiver applies the appropriate evacuation techniques for the neurogenic bladder	Performs the intermittent catheterization technique.
(sterile intermittent catheterization).	Ensures aseptic conditions throughout the procedure
The caregiver is able to evaluate the characteristics of the urine.	Evaluates the characteristics of urine (quantity, color and consistency).
Upper airway scenario	
The caregiver is able to correctly handle the tracheostomy tube.	Identifies the different parts that make up the tracheostomy tube.
The caregiver learns to aspirate secretions, assessing their consistency and other characteristics.	Prepares the material for the aspiration of secretions. Performs the suctioning technique. Evaluates the consistency and other characteristics of secretions.
The caregiver identifies what action to take when a mucous plug is encountered.	Identifies the AMBU and knows how to use it.

to the training they received from the health professionals: upper airway care, neurogenic bladder care, neurogenic bowel care, mobilization, and PIU prevention and treatment.

#### Phase 2

The levels of education of the participants in the second phase of the study (i.e., the caregivers who participated in the simulation) were as follows: primary school (30%), high school graduate (20%), and university education (50%). The professional occupation of the participants at the time of the study were as follows: self-employed (10%), employed at an organization (60%), and unemployed (30%), although the unemployed participants were engaged in domestic activities and family care. The mean period from the time of the relative's SCI to the initiation of the study was 7 months; in 50% of the cases, the time between the SCI and the beginning of the study was 4 months or less; for 20%, it was between 4 and 8 months; and for 30%, it was more than 8 months. In terms of the caregivers' perceptions of their ability to provide assistance to their relatives, 30% felt capable, while 70% said they were not able to provide assistance. The sociodemographic characteristics of each primary caregiver who participated in the second phase of the study are shown in Table 1.

The ICC obtained for the individual scenarios was 0.970 (very good) for the upper airway scenario, 0.975 (very good) for the neurogenic bladder scenario, 0.940 (very good) for the neurogenic bowel scenario, and 0.965 (very good) for the mobilization and PIU scenario.

Table 4 Clinical simulation scenarios, background information, and scenario description for each simulated case

	•	a	
Scenario	Participants/total of caregivers	Information provided prior to the scenario	Development of the scenario
Upper airway	01/L	Lying in bed, the patient begins to cough persistently and produces secretions that need to be aspired.	The simulator starts with severe dyspnea caused by a mucus plug. Coughing does not effectively expel it, and SatO2 decreases. The caregiver then proceeds to aspirate the secretions, which are very thick and yellowish. The mucus plug persists, and the caregiver must now administer ventilation with the manual resuscitator, change the inner cannula of the tracheostomy, and ensure that it is permeable.
Neurogenic bladder	8/10	At home, the patient begins to experience a severe headache, palpitations, chills, and malaise.	The simulator says: "T m feeling really bad, my head hurts." Tachycardia and elevated temperature are programmed. The caregiver evacuates the patient's bladder using intermittent catheterization and notices a small amount of very turbid urine in the collection bag. After evacuation, the caregiver considers the possibility that the patient's discomfort is due to a possible urinary tract infection and, in that case, a doctor should be contacted to perform a urine culture.
Neurogenic bowel	6/10	After 4 days without defecating, the relative is restless and experiences malaise.	The simulator starts to complain and tells the participant that the doctor said to administer an enema when that situation occurs. The caregiver administers an enema using rectal probing. Before inserting the probe, the caregiver performs a rectal exam and finds fecal impaction. The simulator experiences nausea, complains of a headache, and shows nervousness.
Mobilization and PIU	4/10	The caregiver is at home. It is 16:00, and the patient has to be put to bed.	This scenario is performed by an actor. The actor is in a wheelchair and asks to be put to bed because he wants to rest. The actor must be undressed. The actor asks the caregiver to be attentive to the areas of the body at risk of developing PIU (bony prominences). The caregiver detects redness in the sacral area and has to move the actor by performing a postural change to lateral decubitus.

**Table 5** Pre test and post testresults of the interventions for

results of the interventions for
each of the scenarios

Scenario	Action	Pre test		Post test		Bootstrap*			Pre test–Post test		
		Mean	SD	Mean	SD	Mean	95% CI		t	р	d
Upper airway	1	1.29	0.65	3.00	0.00	1.71	1.57	1.86	9.29	0.001	3.51
(n = 7)	2	1.29	0.49	4.14	0.69	2.86	2.57	3.14	10.95	0.001	4.14
	3	1.29	0.49	3.57	0.53	2.29	2.00	2.57	8.00	00.01	3.02
	4	0.14	0.38	0.71	0.49	0.57	0.43	0.71	2.83	0.018	1.06
	5	1.29	0.49	2.86	0.69	1.57	1.29	1.86	7.78	0.001	2.94
Neurogenic bladder	1	1.25	0.46	3.63	0.74	2,38	2,00	2,63	9.03	0.001	3.19
(n=8)	2	0.13	0.35	1.00	0.0	0,88	0,63	0,88	7.00	0.001	2.47
	3	1.25	0.46	4.75	0.46	3,50	3,13	3,88	13.09	0.001	4.63
	4	1.25	0.46	4.38	0.52	3,13	2,75	3,50	13.79	0.001	4.87
	5	1.13	0.35	3.75	0.71	2,63	2,50	2,75	14.35	0.001	5.07
	6	1.13	0.35	3.63	0.52	2,50	2,25	2,75	13.23	0.001	4.67
Neurogenic bowel	1	1.17	0.41	3.50	0.55	2.33	2.17	2.67	11.07	0.001	4.52
(n = 6)	2	1.17	0.41	4.17	0.41	3.00	2.67	3.33	11.62	0.001	4.75
	3	0.33	0.52	1.00	0.00	0.67	0.50	0.67	3.16	0.001	1.29
	4	1.17	0.41	4.50	0.41	2.83	2.50	2.83	17.00	0.001	6.94
	5	0.33	0.52	0.79	0.52	0.33	0.17	0.83	1.58	0.110	0.64
	6	1.17	0.41	3.17	0.41	2.33	2.17	2.67	11.07	0.001	4.52
	7	1.33	0.82	3.00	0.63	1.67	1.33	1.83	7.90	0.001	3.23
Mobilization and PIU $(n = 4)$	1	1.50	1.00	4.00	0.82	2.00	1.5	2.5	4.90	0.001	2.45
	2	2.00	0.82	4.00	0.82	2.25	2.25	2.75	9.00	0.001	4.5
	3	2.00	1.41	4.25	0.50	2.25	2.25	2.75	9.00	0.001	4.5
	4	2.00	1.41	3.75	0.96	2.25	2.25	2.75	9.00	0.001	4.5

\*Bootstrap results are based on 2000 bootstrap samples

The primary caregivers who participated in this study acquired most of the competencies covered in the clinical simulation scenarios. Outcome measures for pre intervention and post intervention are provided in Table 5.

In the upper airway scenario, the caregivers obtained a higher average score on the post test than the pre test, and the differences were statistically significant (p < 0.001) with a strong size effect (d > 2.70) except for intervention 4. For this intervention ("evaluate the consistency and other characteristics of the secretions"), which was a dichotomous variable, 71% of the participants reported that they knew how to perform this intervention at the end of the training phase, as compared with 14% before the training.

In the neurogenic bladder scenario, the caregivers obtained a higher average score on the post test than on the pre test, and the differences were statistically significant (p < 0.001) with a strong effect size (d > 2.70) except for intervention 2. For this intervention ("indicate the correct pattern of liquid ingestion"), which was a dichotomous variable, 100% of the participants reported knowing how to perform the intervention at the end of the training, compared with 13% before the training.

For the neurogenic bowel scenario, the caregivers obtained a higher average score on the post test than on the

pre test, and the differences were statistically significant (p < 0.001), with a strong size effect (d > 2.70) except for interventions 3 ("place in the lateral decubitus position") and 5 ("first perform a digital rectal examination"). For intervention 3 ("place in the lateral decubitus position"), which was a dichotomous variable, 100% of the participants reported knowing how to perform this intervention at the end of training, compared with 33% before training. For intervention 5 ("first perform a digital rectal examination"), which was a dichotomous variable, 79% of the participants reported that they knew how to perform this intervention at the end of the training, compared with 33% before the training.

For the mobilization and PIU scenario, the caregivers obtained a higher average score on the post test than the pre test, and the difference was statistically significant (p < 0.001) with a strong effect size (d > 2.70).

#### Discussion

The results of our study showed an increase in the caregivers' competence levels for almost all of the proposed interventions. The experts' analyses before and after the training showed statistically significant increases in the aspects evaluated. The caregivers learned technical skills, such as preparing materials, or the performance of the technique itself, such as intermittent catheterization or enema administration, more quickly with SBL. The increase in the acquisition of manual clinical skills through simulation has been shown in studies [32] involving health professionals but not caregivers of people with SCI. Similar to the results from the present study, a recent systematic review has underlined that the range of interventions (including family training, problem-solving training, and support groups) have been shown to provide benefits for the family caregiver quality of life [33].

A recent study analyzed the needs of relatives of people with SCI [8] and found a need for greater caregiver involvement in the rehabilitation and the preparation for hospital discharge, but the training methods used in that study were not as effective as the SBL used in the present study. Some authors [8, 32, 34, 35] have suggested that caregivers should receive training during the patient's rehabilitation period to increase the patient's quality of life and improve their adaptation at home.

Some studies have explored the use of SBL for family caregivers of people with various health problems [9, 10]. Recently, a study evaluated the effectiveness of a SBL program to train new parents on how to manage fever in children, comparing this approach to learning through written material [36]. The development of simulation scenarios significantly improved knowledge and the development of fever-management skills. The study recommended that pediatric services provide simulation-based education to help parents successfully address fever at home.

For the acquisition of knowledge (material identification, prevention measures, symptom and sign detection, etc.), the learning gains were less impressive. Perhaps this difference should be taken into account in future training programs for informal caregivers of patients with SCI and other pathologies, and a slightly longer chronogram should be designed to promote a more gradual learning curve. Lastly, it should be highlighted that in the interventions for clinical scenarios that required dexterity, the caregivers generally did not achieve the maximum level of competence. Thus, new training proposals that provide more repetitions and training could be developed, as expertize is achieved through training over time and the time it takes to turn an apprentice into an expert is difficult to estimate [37].

For this study, the development of an evaluation tool was needed, as a specific tool was required by our research. There is a tool called the Care Ability Inventory (CAI<sup>©</sup>), described by Nkongho [38], which measures the caregivers' ability to care for people with chronic diseases in terms of

their knowledge, relevance, and patience. However, this tool was not specific enough for our objectives and our sample. First, our caregivers were in an acute phase of grief, and second, the tool could not be adapted to the teaching methodology using high-fidelity simulations proposed in this study.

The results showed that our tool was reliable; according to the levels of agreement described by Landis and Koch [39], the interobserver agreement scores obtained were "good" and "very good" for most of the items evaluated by the four expert observers. In future research, these interventions could be adjusted and redefined so that the evaluators' interpretation is even more homogeneous.

Lastly, it should be noted that the participation of an actor in the mobilization and PIU scenario facilitated learning, as simulation with standardized patients allows for a more realistic immersion and achieves higher fidelity. A study of clinical simulation training in obstetric emergencies [40] compared training using high-fidelity mannequins versus standardized patients and found that the perception of security and communication during postpartum hemorrhage improved to a significantly greater degree after training with patient actors than with mannequins. However, the trainees' perceptions of their ability to care for a patient did not show significant differences [40]. In our study, we only used an actor for a clinical simulation scenario because the other scenarios included demonstrations of invasive techniques. Contrary to the study by Crofts, we found a statistically significant improvement in the performance of this scenario.

Clinical simulation as a learning methodology is not intended for supplanting the in situ training caregivers receive at the hospital; instead, it should be considered as a complementary approach during the training period. A complete training system should be planned in which caregivers first acquire a competence through simulation and then apply those skills in the caring of their relatives. This process would increase safety and improve the learner's confidence during the training process, thus avoiding stressful situations for both the primary caregiver and the patient.

In our study, we observed that during the debriefings, informal mutual aid groups spontaneously formed, which allowed peers to share their experiences, concerns, and fears. In addition, introducing experienced primary caregivers to the group provided points of reference and motivated new caregivers into believing that they could also acquire the skills. Munn-Giddings and McVicar [41], in their study of self-help groups and caregivers, comment that these groups create a safe environment for sharing knowledge and seeking information and advice from others. Caregivers who attend these groups feel more confident about their knowledge, skills, and abilities and in their interactions with health professionals, as the group generates opportunities for them to discuss their personal situations and to encounter different perspectives on caring.

The results of this research study could be partially extrapolated to other individuals with a disability who require care and for whom a caregiver is indispensable. Providing training will boost security, prevent complications, and will most likely result in a better quality of life for individuals with disabilities and their caregivers.

As the results of our study revealed, the caregivers of people with SCI successfully acquired the skills needed for care procedures; therefore, it can be concluded that clinical simulation is a useful and effective learning tool for caregivers.

One limitation of our study was the sample size. It was difficult to gather participants because of their limited availability and free time and because of the strict inclusion criteria established to create a homogeneous sample. However, having a highly controlled sample allowed us to improve the quality of the research, because the clinical simulation, unlike other learning systems that can reach a large number of people, was personalized and adjusted for small working groups.

Another limitation was related to objectively evaluating the acquisition of competences using only a few simulation sessions. Normally, SBL requires repeated practice to achieve an adequate competence level; however, repeated practice could produce a bias, as each participant could have experienced the scenario on multiple occasions. We believe that providing additional practice would have substantially overestimated the results of the study.

The use of a questionnaire or a focus group after the simulation would have been beneficial, or perhaps the conversations from the posterior debriefings could have been analyzed. However, this was not done at that time. This is another limitation that must be noted.

In future research, we plan to establish a continuous training program with clinical simulation at the NHP to monitor the learning experiences of caregivers throughout their entire hospital stay, until the patient with SCI is discharged from the hospital, and compare it with that of a control group that has not been trained with clinical simulation. Ideally, a real system of continuous assistance to the patient and training for the caregiver would be created. This system would start once the lesion has been diagnosed at a community hospital, and the information would then be sent to the NHP. Upon the patient's discharge from the NHP, the health service from each community would provide a support system to promote the patient's adaptation to life outside the hospital and would continue with the primary caregivers' training from the point they had reached at the NHP.

#### Data archiving

The datasets generated and analyzed during the current study are available from the corresponding author (JLDA) on reasonable request. However, most of the data generated or analyzed during this study are included in this published article [and its Supplementary Information files].

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Author contributions LJR was responsible for designing scenarios, extracting and analyzing data, interpreting results, and writing the report. MPR was responsible for designing scenarios and conducting the simulations experiences in HNPT hospital. MCH contributed to data extraction in the field and provided feedback on the report. NPA contributed to design scenarios and run them in HNPT. CLC contributed to analyze data and write the report. JLDA was responsible for conducting and designing the research, write part of the discussion section, and review the manuscript before sending it.

#### **Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

**Statement of Ethics** We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research. This research fulfilled the requirements of the Declaration of Helsinki and was approved by the Ethics Committee of the NHP and the Catholic University of Murcia. All of the participants were informed about their participation and signed a form indicating their informed consent and authorizing the video recording of their performances in the simulations and the broadcasting of these recordings for scientific purposes.

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