Does prior exposure to clinical critical events influence stress reactions to simulation session in nursing students: A case-control study

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DOES PRIOR EXPOSURE TO CLINICAL CRITICAL EVENTS INFLUENCE STRESS REACTIONS TO SIMULATION SESSION IN NURSING STUDENTS: A CASE-CONTROL STUDY


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Declaration of competing interest

All authors declare they have no conflict of interest to disclose.

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Couarraze S.: Study concept, study design, data acquisition, data analysis and interpretation, statistical analysis, manuscript preparation, manuscript editing, revising manuscript critically for important intellectual content.

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**Ethical issues**

Written permission was obtained from the director of nursing school. All participants were informed that their participation was voluntary to complete the questionnaire and they were free to withdraw at any time. They were asked to sign a questionnaire confirming their authorization and participation for responding to the French collected of data protection. All information has been treated confidentially. This study obtained the written permission N°*CERNI-Université fédérale de Toulouse-2016-009* of the ethical committee of the federal university of Toulouse. This study is registered on N°1968300 of the French declaration of conformity in health study.

**Figure Legends**

Figure 1: Flow chart of the study

Figure 2: Perceived stress levels before, during and expected after the simulation-based education

Figure 3: Perceived stress levels 4 months after the simulation-based education during a critical clinical event
Abstract

Background: Simulation is a pedagogical method known to be a generator of stress, that could be influenced by previous stressful experiences.

Objectives: The purpose of this study was to determine the impact of previous experience with a clinical critical event on the stress experienced by nursing students during simulation session of critical events, and on the stress experienced during clinical critical events subsequent to the training.

Design: Observational case-control study.

Settings: Four critical event scenarios were created using full-scale simulation.

Participants: Two hundred and fifteen undergraduate nursing students of semester four. The control group (n = 112) consisted of learners who had not previously experienced a critical event. The prior exposure group (n = 103) consisted of learners who had experienced a critical event prior to the course.

Methods: Stress levels were assessed using the self-report stress numerical rating scale-11.

Results: There was no significant difference in the level of stress between the prior exposure group and the control group before, during or expected after the simulation session. A significant decrease in stress was observed in both groups from before the course to during the session (p < 0.05) and expected after the session (p < 0.05). There was no significant difference between the expected post-session stress level and the stress levels reported four months after the training (p = 0.966). At four months, there was no significant difference in stress levels between the groups (p = 0.212).
Conclusions: The prior experience of a clinical critical event before a simulation course did not influence their reported stress level during the simulation session. Conversely, simulation-based training of critical situations appears to reduce the level of self-assessed stress during critical events in clinical practice after the training.

Keywords: Simulation training, stress, nursing student, critical care
Introduction

The use of simulation for training health professionals has become an important component of both initial and continuing education (Nehring and Lashley, 2009; Nestel, 2017; Rosen, 2008; Rothgeb, 2008). In recent years, nursing education in France has been changing, moving from a vocational approach towards integration of training programs into the university setting. With this major change, training programs, particularly those for Nursing Students (NS), have been reviewed and re-engineered. Simulation-Based Education (SBE) is increasingly deemed necessary for NS, as it allows them to practice carrying out simple procedures such as intravenous access, as well as to work on human factors such as teamwork and interprofessionalism. The realistic environment that can be reproduced in simulations makes it possible to train the students in the management of urgent and/or rare critical events.

McCaughey and Traynor (2010) argue that SBE has a positive impact on students' perceptions of their professional development, particularly with regard to learning through reflecting on their mistakes. However, despite the demonstrated positive impact of simulation on learning and subsequent performance (Cook et al., 2012, 2011), there is also increasing research showing that simulation can be quite stressful for learners (Cantrell et al., 2017; Geeraerts et al., 2017). Among students’ stress triggers are the fear of making mistakes, personal inadequacy (Pagana, 1988) perceived lack of clinical skills (Hamill, 1995), clinical reasoning during critical events, and self-confidence (Kaddoura, 2010). In some cases, this stress can lead to cognitive overload and poorer learning outcomes (Bong et al., 2016). This raises questions as to whether there are groups of learners who are susceptible to having greater stress responses to simulation-based learning experiences, notably those who have previously encountered critical events in the clinical setting. Health professionals are regularly exposed to stressful and potentially traumatic events as part of their work. What is less evident is the impact of this prior exposure on subsequent emotional experiences during SBE related to urgent and/or critical events. Previous studies, with police recruits and communicators, show
mixed findings regarding the relationship between prior exposure to potentially traumatizing events and subsequent anxiety responses to simulated events (Regehr et al., 2013, 2007). Conversely, the role of simulation in preparing learners to manage their stress responses to subsequent critical events has not been determined. Learning to recognize and manage emotions in the face of a critical event through simulation is a focus of the current research. Moderate to high levels of perceived stress have been observed in NS during their studies (Labrague et al., 2017). Using simulation appears to improve these stress management skills, in particular as a result of the debriefing session (Ericsson, 2004). The transactional model of stress highlights a link between individuals and their environment and the resources they can develop to cope with stressful situations (Lazarus and Folkman, 1984). In health professions education, it is unclear whether previously experiencing stressful clinical situations enable learners to develop stress management skills. This increased competence in emotional regulation skills would manifest itself in decreased stress responses during later stressful situations. On the other hand, a pedagogical device allowing the development of personal resources to deal with stressful situations in environments that are safe for the patient and the learners would be particularly relevant.

The main objective of this study was to evaluate the impact of having previously experienced a clinical critical event on self-reported stress related to a SBE session. We hypothesized that prior exposure to clinical critical events would influence the stress experienced in anticipation of, during, and following SBE sessions.

The secondary objective of this study focused on the evaluation of stress levels at different times of the study and their evolution over time.
**Methods**

**Design of the study:**

We conducted a prospective single-center observational case-control study on a simulation-based training intervention from April to May 2017 (Figure 1). This study was approved by the Ethics Committee of the University of Toulouse Jean Jaures (CERNI-Université fédérale de Toulouse- number 2016-009, approval without specific comments). The “prior exposure” group consisted of students who had experienced a clinical critical event prior to training. The “control group” consisted of students who had never experienced a critical event in their clinical practice. A critical event was defined as “an occurrence that could have led (if not discovered or corrected in time) or did lead to an undesirable outcome, ranging from increased length of hospital stay to death” (Maaløe et al., 2006). The outcome measures were self-reported stress levels before, during, immediately after the simulation-based session, as well as 4 months after training for those who subsequently experienced a clinical critical event following the simulation session regardless of when that event occurred within the 4-month period. We established this four-month period because it corresponded to the end of a clinical traineeship period and before the start of the fourth semester exam period.

**Study site:**

The Nursing School at the University Hospital of Toulouse carries out the practical training in emergency care, with the participation of the Fire Department. The nursing program lasts three years (divided into six semesters) during which the NS get practical instruction on critical events in first and third year of the program.

**Participants:**

All 253 students enrolled in the 4th semester of the 2015-2018 class participated in the simulation activity. The class was divided into teams of 8 to 10 learners. Participants paired...
up to recreate the nurse/caregiver pair that is normally present in clinical practice. The training lasted four hours, with five groups of 8-10 students at each session. Each group was led by a trainer of the nursing school and an experienced in simulation educator from the Fire Department.

**Intervention:**

During the training activity, four scenarios were simulated. These scenarios lasted 15 to 20 minutes and were followed by a 30 to 40 minutes debriefing. The PEARLS (Promoting Excellence and Reflective Learning in Simulation) debriefing model was used as described by Eppich and Cheng (2015). The aim was to put the students in a reflexive situation (Schön, 1983) with the facilitators using the “good judgment” approach (Rudolph et al., 2007). Thus, the trainers provided the nursing students factual and objective feedback on the actions they carried out based on the learning objectives. Of the methods presented in the PEARLS framework, the method of advocacy-inquiry was favored as a facilitation technique during the debriefings (Eppich and Cheng, 2015). This communicative technique consists in exposing the actions visualized by the trainer, confronting them with the evidence-based guidelines and finally stimulating the participants’ reflexivity. Educator questioning incorporates a non-judgmental approach, as the manner in which nursing students are questioned can impact their learning and stress levels (Neill and Wotton, 2011). In addition, the atmosphere and climate at the time of debriefing can have an impact on the effectiveness of the debriefing (Wickers, 2010).

The course was designed with an increasing complexity of the cases. The objectives were shared with participants, separated into technical and non-technical skills. This was the first simulation-based training for these nursing students. They did not have any further simulation training in the four months following this particular training. The details of the cases, the
educational goals and the type of simulation used are presented in Table 1. Scenarios were built according to recommendations for nursing simulation (Waxman, 2010).

**Data:**

Students were asked to assess their stress with the Stress Numerical Rating Scale-11 (SNRS-11). SNRS-11 is a scale ranging from 0 to 10, with 0 being the lowest and 10 the highest level of stress that individuals can imagine. The SNRS-11 scale has demonstrated acceptable validity and reliability in assessing momentary perceived stress levels in adolescents and adults, as well as strong correlations with longer, commonly used measures of anxiety, such as the State-Trait Anxiety Inventory (Karvounides et al., 2016).

During the simulation-based intervention, the stress levels of the learners were assessed on three separate occasions for both groups:

- **Before the training:** if they had previously experienced a clinical critical event, they were asked to recall their stress levels during that situation. If the students had not experienced a critical situation, they were asked to estimate what their stress levels would have been in such a situation,

- **During** the critical situation simulation sessions; participants completed the scale right after the training,

- **After the training** they were asked to estimate their anticipated stress levels if they should experience a critical situation in clinical practice,

Students were also contacted 4 months after the training to find out if they had experienced a critical situation in their clinical practice subsequent to the simulation training. Those who had experienced such an event were invited to report their stress levels experienced during this event using the SNRS-11 (n = 51).
Statistical analysis:

Data were expressed in mean and standard deviation (SD) or percentage when appropriate. In order to compare the different stress levels of each group (control and prior exposure), a repeated measures ANOVA using the free software Jamovi 1.1.9.0 was performed. An independent sample t-test was performed to compare the stress levels of the students at 4 months after the training. A Spearman test was carried out in order to establish a correlation between the values of stress levels at each time. The value of $p \leq 0.05$ was used as the threshold of significance.

Results

Of the 253 students participating in the simulation sessions, 215 students agreed to participate in the study. Of this sample, 47.9% of the students ($n = 103$) had experienced a critical event in clinical practice prior to the training and thus were assigned to the prior exposure group. The remainder of the students (52.1%, $n = 112$) had never experienced a critical event in clinical practice and were thus assigned to the control group. Four months after the training, 111 of the initial cohort completed the survey. Of this group, 45.9% of the students ($n = 51$) had experienced a critical situation since the simulation sessions. The characteristics of the control and prior exposure groups are equivalent in terms of age, gender and status with regard to nursing education.

In the control group, the mean SNRS-11 estimated by students, had they experienced a critical clinical situation prior to training, was 7.39 (SD = 2.37). In the prior exposure group, the mean level of stress was the same 7.30 (SD = 2.56). During the training, the mean SNRS-11 score for the control group was 4.45 (SD = 2.31) and 4.35 (SD = 2.56) for the prior exposure group. At the end of the training, the mean level of stress expected in the event of a subsequent critical situation was 5.66 (SD = 1.89) for the control group and 5.60 (SD = 2.39)
for the prior exposure group. The results of the ANOVA on the stress levels of the control and prior exposure groups did not reveal any significant difference for the group ($F(2) = 0.007$, $p = 0.993$), nor any significant interaction of group by time ($F(1) = 0.111$, $p = 0.740$) (Figure 2).

Four months after the training, amongst the 51 students who had experienced a clinical critical event following the simulation course, the mean perceived level of stress during these events was 5.61 (SD = 2.01). This was not significantly different from the expected level of stress for crisis situations they reported at the end of the course ($p = 0.966$). Of the 51 students who had experienced a critical situation in the 4 months following the simulation session, 23 had experienced a critical situation prior to training. There was no significant difference in stress levels between the control and prior exposure groups ($p = 0.212$) (Figure 3).

For both groups, the level of perceived stress decreased significantly from the prior critical event in clinical practice (actual or estimated) to those experienced during the simulation ($p < 0.001$). As well, stress levels decreased significantly from before the simulation session to after the training, when they were asked to estimate their anticipated stress levels should they subsequently experience a critical situation in clinical practice ($p < 0.001$). For students who experienced a critical clinical event before and after training, their stress levels were significantly lower for the post-simulation critical event than for the pre-simulation critical event ($p < 0.006$).

Discussion

The primary purpose of this study was to examine the perceived stress levels of nursing students related to simulation sessions, and to determine whether prior exposure to critical events in the clinical settings affected those stress levels. During the simulation sessions, we
found no significant difference between the control group that had not experienced a clinical
critical event and the prior exposure group that had experienced a clinical critical event prior
to the training. Both groups reported similar stress levels in anticipation of, during-, as well as
following the simulation sessions. Furthermore, in learners who did experience a critical event
following the simulation session, the reported stress levels were the same regardless of
whether they had previously encountered a critical situation (prior exposure group) or not
(control group).

A secondary objective of the study was to determine whether perceived levels of stress in
response to simulated and real critical events changed over time. Following the simulation
session, learners in both groups estimated they would have lower stress levels during a future
critical event than what they reported prior to the simulations. Furthermore, we observed a
significant decrease in stress level in response to a clinical critical event from before to after
the simulation session.

These findings suggest that previous experience of a critical event may not affect stress levels
during subsequent SBE sessions. These findings can assuage concerns regarding triggering
greater stress responses during simulation sessions in those with previous experience with
critical events. Furthermore, the results of this study reveal that while simulation sessions can
trigger subjective stress responses in learners, the levels appear to be lower than those
experienced during critical events in clinical practice.

As well, these results suggest that simulation sessions may help inoculate learners to
subsequent stressful events. Consistent with previous research (Oh and Han, 2011), reported
stress levels were lower following the simulation sessions compared to prior to the sessions.
The results of this study add to previous findings by showing that subsequent stress responses
to critical events were not further decreased in those who had previously encountered critical
events. This suggests that mere exposure to critical events may not be sufficient to reduce
subsequent stress responses, given that the self-reported stress levels were equal between the
control and the prior exposure group. Rather, structured educational sessions with debriefing,
even if they engender stress responses in learners, can prepare these learners for the emotional
experience of encountering real critical events. During full-scale simulation sessions, because
participants are fully immersed in a replicated work environment followed by situation-
specific feedback that touches on emotional reactions, this might facilitate the development of
stress management skills more readily than do real clinical situations that allow less time for
reflection and feedback. Additional research, explicitly aimed at investigating the direct
effects of simulation on subsequent emotional reactions to critical events in the clinical
setting, is required to further explore this potential role of simulation.

Simulation sessions may better prepare the learners emotionally, compared to mere exposure,
through two mechanisms. The first is that it increases their skills to deal with the demands of
a critical situation (Cook et al., 2012, 2011). As well, simulation sessions can increase a
learner’s sense of self-efficacy (Bandura, 1982, 1977; Loriot et al., 2018; Oh and Han, 2011).
A leading theory suggests that stress responses are the result of a cognitive appraisal of the
demands being placed on the individual followed by the appraisal of the resources available to
deal with these demands (Loriot et al., 2018). When the demands are assessed as outweighing
the resources, stress responses are greater (Tomaka et al., 1993). Simulation sessions, by
providing learners with enhanced skills and greater self-efficacy, may lead to a perception of
lower demands accompanied by greater resources, thereby reducing the subjective experience
of stress. Therefore, in learners who are regularly confronted with critical situations,
simulations can be a means to accelerate experiential development in order to better perform
in critical practice. It is not always possible to conduct a learning-oriented debriefing in
clinical practice. This debriefing, which is crucial and necessary for the acquisition and/or development of skills (Savoldelli et al., 2006), is systematized during a simulation session. Our results are in line with the recent study of El Khamali et al. (2018) showing the efficacy of simulation education for the management of stress at work in intensive care unit nurses.

This study has some limitations. Physiological indicators of stress such as heart rate variability or salivary cortisol were not measured (Geeraerts et al., 2017). For practical reasons and considering the cohort size, self-reports by the students was chosen. Further research could be targeted towards recreating the findings with the physiological responses. It should be noted, however, that subjective experiences are an essential component to the stress response, and have been associated with performance decrements (LeBlanc et al., 2005). A second limitation is that the current study was conducted with one cohort of student from a single study. Further studies across different cohorts and simulation programs are needed in order to be able to generalize of the results. Finally, the performance of the students was not measured in this cohort. That said, previous research has shown that stress can negatively impact performance in a number of settings (Judd et al., 2019; Lees and Lal, 2017; Vine et al., 2015). Further research could look at the impact of simulation and explicit stress management interventions on performance in addition to subsequent stress responses. Finally, the sample size of the cohort did not allow targeting individual sources of stress and differentiate the progress resulting from simulation teaching on stress or from the natural development of skills during nursing schooling. The study period was however relatively short (4 months), and the expertise in clinical critical event management in such a short period of time is not likely to importantly improve. The stress expected from students has probably dropped regardless their clinical experience.
Conclusion

The prior experience of a critical event in clinical practice does not appear to influence nursing students' self-reported stress levels during subsequent SBE, nor their stress levels during a critical event in the 4 months following the SBE. These findings can assuage concerns regarding triggering greater stress responses during simulation sessions in those with previous experience with critical events. Furthermore, simulation sessions, compared to mere exposure, may better prepare learners for the emotional experience of critical events in the clinical environments.
References


Figure Legends

Figure 1: Flow chart of the study
Figure 2: Perceived stress levels before, during and expected after the simulation-based education.
Figure 3: Perceived stress levels 4 months after the simulation-based education during a critical clinical event
Figure 1: Flow chart of the study

Simulation-Based Education (SBE) of critical situations
\( n = 253 \)

Previous experience of clinical critical event before the course?

YES
\( n = 103 \)
Prior exposure group

Refuse to participate in the study
\( n = 38 \)

NO
\( n = 112 \)
Control group

Assessment of stress levels during previous clinical critical event

Assessment of hypothetical stress levels the student felt they may have experienced if they would have faced a clinical critical event

Assessment of stress levels before, during and expected after session
\( n = 215 \)

\( n = 103 \)

Students who have experienced a clinical critical event 4 months after training
\( n = 51 \)

Assessment of stress levels during this clinical critical event

\( n = 23 \)

\( n = 28 \)
Figure 2: Perceived stress levels before, during and expected after the simulation-based education.
Figure 3: Perceived stress levels 4 months after the simulation-based education during a critical clinical event.
**Table 1: Simulation scenarios**

<table>
<thead>
<tr>
<th>Scenario number</th>
<th>Main theme</th>
<th>Type of simulation</th>
<th>Educational goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chest pain</td>
<td>Standardized patient</td>
<td><strong>Technical skills</strong>&lt;br&gt;- Clinical reasoning&lt;br&gt;- Examination of the patient&lt;br&gt;- Transmission of patient reports to the emergency call reception and dispatch center with SAED</td>
</tr>
</tbody>
</table>
| 2               | Cardiac arrest     | Full-scale simulation with low-fidelity mannequin | **Technical skills**<br>- CPR: cardiac massage, insufflation with BVM<br>- Inserting a peripheral IV<br>- Adrenaline preparation  
                 |                    |                                          | **Non-technical skills**<br>- Clinical reasoning<br>- Calling for help<br>- Transmission of patient reports to the emergency call reception and dispatch center with SAED |
| 3               | Hypoglycemia       | Standardized patient                    | **Technical skills**<br>- Installation adapted to the state of consciousness<br>- Inserting an IV<br>- Preparation of glucose 30% 
                 |                    |                                          | **Non-technical skills**<br>- Clinical reasoning<br>- Transmission of patient reports to the doctor with SAED<br>- Application of a nursing emergency care protocol<br>- Traceability in the care record |
| 4               | Lower limb trauma  | Standardized patient                    | **Technical skills**<br>- Immobilization<br>- Inserting an IV<br>- Preparation of analgesics 
                 |                    |                                          | **Non-technical skills**<br>- Clinical reasoning<br>- Transmission of patient reports to the doctor with SAED<br>- Application of a nursing emergency care protocol<br>- Traceability in the care record |

CPR: CardioPulmonary Resuscitation  
BVM: Bag Valve Mask  
IV: IntraVenous  
SAED: Situation, Antecedents, Evaluation, Demand