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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.

### **Contribution:**

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.*

Saint-Jean M.: *Study concept, revising manuscript critically for important intellectual content and supervision.*

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Houze-Cerfon C.H.: *Manuscript editing, revising manuscript critically for important intellectual content.*

LeBlanc V.: *data analysis and interpretation, statistical analysis, manuscript preparation, manuscript editing, revising manuscript critically for important intellectual content, manuscript review.*

Geeraerts T.: *Study concept, study design, manuscript editing, revising manuscript critically for important intellectual content, manuscript review and supervision.*

### **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

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

3

4 **Abstract**

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

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

11 *Design:* Observational case-control study.

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

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

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

18 *Results:* There was no significant difference in the level of stress between the prior exposure  
19 group and the control group before, during or expected after the simulation session. A  
20 significant decrease in stress was observed in both groups from before the course to during  
21 the session (p < 0.05) and expected after the session (p < 0.05). There was no significant  
22 difference between the expected post-session stress level and the stress levels reported four  
23 months after the training (p = 0.966). At four months, there was no significant difference in  
24 stress levels between the groups (p = 0.212).

25 *Conclusions:* The prior experience of a clinical critical event before a simulation course did  
26 not influence their reported stress level during the simulation session. Conversely, simulation-  
27 based training of critical situations appears to reduce the level of self-assessed stress during  
28 critical events in clinical practice after the training.

29

30 **Keywords:** Simulation training, stress, nursing student, critical care

31

## 32 **Introduction**

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

43 McCaughey and Traynor (2010) argue that SBE has a positive impact on students' perceptions  
44 of their professional development, particularly with regard to learning through reflecting on  
45 their mistakes. However, despite the demonstrated positive impact of simulation on learning  
46 and subsequent performance (Cook et al., 2012, 2011), there is also increasing research  
47 showing that simulation can be quite stressful for learners (Cantrell et al., 2017; Geeraerts et  
48 al., 2017). Among students' stress triggers are the fear of making mistakes, personal  
49 inadequacy (Pagana, 1988) perceived lack of clinical skills (Hamill, 1995), clinical reasoning  
50 during critical events, and self-confidence (Kaddoura, 2010). In some cases, this stress can  
51 lead to cognitive overload and poorer learning outcomes (Bong et al., 2016). This raises  
52 questions as to whether there are groups of learners who are susceptible to having greater  
53 stress responses to simulation-based learning experiences, notably those who have previously  
54 encountered critical events in the clinical setting. Health professionals are regularly exposed  
55 to stressful and potentially traumatic events as part of their work. What is less evident is the  
56 impact of this prior exposure on subsequent emotional experiences during SBE related to  
57 urgent and/or critical events. Previous studies, with police recruits and communicators, show

58 mixed findings regarding the relationship between prior exposure to potentially traumatizing  
59 events and subsequent anxiety responses to simulated events (Regehr et al., 2013, 2007).

60 Conversely, the role of simulation in preparing learners to manage their stress responses to  
61 subsequent critical events has not been determined. Learning to recognize and manage  
62 emotions in the face of a critical event through simulation is a focus of the current research.  
63 Moderate to high levels of perceived stress have been observed in NS during their studies  
64 (Labrague et al., 2017). Using simulation appears to improve these stress management skills,  
65 in particular as a result of the debriefing session (Ericsson, 2004). The transactional model of  
66 stress highlights a link between individuals and their environment and the resources they can  
67 develop to cope with stressful situations (Lazarus and Folkman, 1984). In health professions  
68 education, it is unclear whether previously experiencing stressful clinical situations enable  
69 learners to develop stress management skills. This increased competence in emotional  
70 regulation skills would manifest itself in decreased stress responses during later stressful  
71 situations. On the other hand, a pedagogical device allowing the development of personal  
72 resources to deal with stressful situations in environments that are safe for the patient and the  
73 learners would be particularly relevant.

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

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

80

81

82

83



84 **Methods**

85 Design of the study:

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

100

101 Study site:

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

106

107 Participants:

108 All 253 students enrolled in the 4<sup>th</sup> semester of the 2015-2018 class participated in the  
109 simulation activity. The class was divided into teams of 8 to 10 learners. Participants paired

110 up to recreate the nurse/caregiver pair that is normally present in clinical practice. The  
111 training lasted four hours, with five groups of 8-10 students at each session. Each group was  
112 led by a trainer of the nursing school and an experienced in simulation educator from the Fire  
113 Department.

114

115 Intervention:

116 During the training activity, four scenarios were simulated. These scenarios lasted 15 to 20  
117 minutes and were followed by a 30 to 40 minutes debriefing. The PEARLS (Promoting  
118 Excellence and Reflective Learning in Simulation) debriefing model was used as described by  
119 Eppich and Cheng (2015). The aim was to put the students in a reflexive situation (Schön,  
120 1983) with the facilitators using the “good judgment” approach (Rudolph et al., 2007). Thus,  
121 the trainers provided the nursing students factual and objective feedback on the actions they  
122 carried out based on the learning objectives. Of the methods presented in the PEARLS  
123 framework, the method of advocacy-inquiry was favored as a facilitation technique during the  
124 debriefings (Eppich and Cheng, 2015). This communicative technique consists in exposing  
125 the actions visualized by the trainer, confronting them with the evidence-based guidelines and  
126 finally stimulating the participants' reflexivity. Educator questioning incorporates a non-  
127 judgmental approach, as the manner in which nursing students are questioned can impact their  
128 learning and stress levels (Neill and Wotton, 2011). In addition, the atmosphere and climate at  
129 the time of debriefing can have an impact on the effectiveness of the debriefing (Wickers,  
130 2010).

131

132 The course was designed with an increasing complexity of the cases. The objectives were  
133 shared with participants, separated into technical and non-technical skills. This was the first  
134 simulation-based training for these nursing students. They did not have any further simulation  
135 training in the four months following this particular training. The details of the cases, the

136 educational goals and the type of simulation used are presented in **Table 1**. Scenarios were  
137 built according to recommendations for nursing simulation (Waxman, 2010).

138

139 Data:

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

146

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

- 149 - **Before the training;** if they had previously experienced a clinical critical event, they  
150 were asked to recall their stress levels during that situation. If the students had not  
151 experienced a critical situation, they were asked to estimate what their stress levels  
152 would have been in such a situation,
- 153 - **During** the critical situation simulation sessions; participants completed the scale right  
154 after the training,
- 155 - **After the training** they were asked to estimate their anticipated stress levels if they  
156 should experience a critical situation in clinical practice,

157

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

162

163 Statistical analysis:

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

171

172 **Results**

173 Of the 253 students participating in the simulation sessions, 215 students agreed to participate  
174 in the study. Of this sample, 47.9% of the students (n = 103) had experienced a critical event  
175 in clinical practice prior to the training and thus were assigned to the **prior exposure group**.  
176 The remainder of the students (52,1%, n = 112) had never experienced a critical event in  
177 clinical practice and were thus assigned to the **control group**. Four months after the training,  
178 111 of the initial cohort completed the survey. Of this group, 45.9% of the students (n = 51)  
179 had experienced a critical situation since the simulation sessions. The characteristics of the  
180 control and prior exposure groups are equivalent in terms of age, gender and status with  
181 regard to nursing education.

182 In the control group, the mean SNRS-11 estimated by students, had they experienced a critical  
183 clinical situation prior to training, was 7.39 (SD = 2.37). In the prior exposure group, the  
184 mean level of stress was the same 7.30 (SD = 2.56). During the training, the mean SNRS-11  
185 score for the control group was 4.45 (SD = 2.31) and 4.35 (SD = 2.56) for the prior exposure  
186 group. At the end of the training, the mean level of stress expected in the event of a  
187 subsequent critical situation was 5.66 (SD = 1.89) for the control group and 5.60 (SD = 2.39)

188 for the prior exposure group. The results of the ANOVA on the stress levels of the control and  
189 prior exposure groups did not revealed any significant difference for the group ( $F(2) = 0.007$ ,  
190  $p = 0.993$ ), nor any significant interaction of group by time ( $F(1) = 0.111$ ,  $p = 0.740$ ) (**Figure**  
191 **2**).

192

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

200

201 For both groups, the level of perceived stress decreased significantly from the prior critical  
202 event in clinical practice (actual or estimated) to those experienced during the simulation ( $p <$   
203  $0.001$ ). As well, stress levels decreased significantly from before the simulation session to  
204 after the training, when they were asked to estimate their anticipated stress levels should they  
205 subsequently experience a critical situation in clinical practice ( $p < 0.001$ ). For students who  
206 experienced a critical clinical event before and after training, their stress levels were  
207 significantly lower for the post-simulation critical event than for the pre-simulation critical  
208 event. ( $p < 0.006$ ).

209

## 210 **Discussion**

211 The primary purpose of this study was to examine the perceived stress levels of nursing  
212 students related to simulation sessions, and to determine whether prior exposure to critical  
213 events in the clinical settings affected those stress levels. During the simulation sessions, we

214 found no significant difference between the control group that had not experienced a clinical  
215 critical event and the prior exposure group that had experienced a clinical critical event prior  
216 to the training. Both groups reported similar stress levels in anticipation of, during-, as well as  
217 following the simulation sessions. Furthermore, in learners who did experience a critical event  
218 following the simulation session, the reported stress levels were the same regardless of  
219 whether they had previously encountered a critical situation (prior exposure group) or not  
220 (control group).

221

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

228

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

235

236 As well, these results suggest that simulation sessions may help inoculate learners to  
237 subsequent stressful events. Consistent with previous research (Oh and Han, 2011), reported  
238 stress levels were lower following the simulation sessions compared to prior to the sessions.  
239 The results of this study add to previous findings by showing that subsequent stress responses

240 to critical events were not further decreased in those who had previously encountered critical  
241 events. This suggests that mere exposure to critical events may not be sufficient to reduce  
242 subsequent stress responses, given that the self-reported stress levels were equal between the  
243 control and the prior exposure group. Rather, structured educational sessions with debriefing,  
244 even if they engender stress responses in learners, can prepare these learners for the emotional  
245 experience of encountering real critical events. During full-scale simulation sessions, because  
246 participants are fully immersed in a replicated work environment followed by situation-  
247 specific feedback that touches on emotional reactions, this might facilitate the development of  
248 stress management skills more readily than do real clinical situations that allow less time for  
249 reflection and feedback. Additional research, explicitly aimed at investigating the direct  
250 effects of simulation on subsequent emotional reactions to critical events in the clinical  
251 setting, is required to further explore this potential role of simulation.

252

253 Simulation sessions may better prepare the learners emotionally, compared to mere exposure,  
254 through two mechanisms. The first is that it increases their skills to deal with the demands of  
255 a critical situation (Cook et al., 2012, 2011). As well, simulation sessions can increase a  
256 learner's sense of self-efficacy (Bandura, 1982, 1977; Loriot et al., 2018; Oh and Han, 2011).  
257 A leading theory suggests that stress responses are the result of a cognitive appraisal of the  
258 demands being placed on the individual followed by the appraisal of the resources available to  
259 deal with these demands (Loriot et al., 2018). When the demands are assessed as outweighing  
260 the resources, stress responses are greater (Tomaka et al., 1993). Simulation sessions, by  
261 providing learners with enhanced skills and greater self-efficacy, may lead to a perception of  
262 lower demands accompanied by greater resources, thereby reducing the subjective experience  
263 of stress. Therefore, in learners who are regularly confronted with critical situations,  
264 simulations can be a means to accelerate experiential development in order to better perform  
265 in critical practice. It is not always possible to conduct a learning-oriented debriefing in

266 clinical practice. This debriefing, which is crucial and necessary for the acquisition and/or  
267 development of skills (Savoldelli et al., 2006), is systematized during a simulation session.  
268 Our results are in line with the recent study of El Khamali et al. (2018) showing the efficacy  
269 of simulation education for the management of stress at work in intensive care unit nurses.

270

271 This study has some limitations. Physiological indicators of stress such as heart rate  
272 variability or salivary cortisol were not measured (Geeraerts et al., 2017). For practical  
273 reasons and considering the cohort size, self-reports by the students was chosen. Further  
274 research could be targeted towards recreating the findings with the physiological responses. It  
275 should be noted, however, that subjective experiences are an essential component to the stress  
276 response, and have been associated with performance decrements (LeBlanc et al., 2005). A  
277 second limitation is that the current study was conducted with one cohort of student from a  
278 single study. Further studies across different cohorts and simulation programs are needed in  
279 order to be able to generalize of the results. Finally, the performance of the students was not  
280 measured in this cohort. That said, previous research has shown that stress can negatively  
281 impact performance in a number of settings (Judd et al., 2019; Lees and Lal, 2017; Vine et al.,  
282 2015). Further research could look at the impact of simulation and explicit stress management  
283 interventions on performance in addition to subsequent stress responses. Finally, the sample  
284 size of the cohort did not allow targeting individual sources of stress and differentiate the  
285 progress resulting from simulation teaching on stress or from the natural development of  
286 skills during nursing schooling. The study period was however relatively short (4 months),  
287 and the expertise in clinical critical event management in such a short period of time is not  
288 likely to importantly improve. The stress expected from students has probably dropped  
289 regardless their clinical experience.

290

291



292

293

294 **Conclusion**

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

302 **References**

- 303 Bandura, A., 1982. Self-efficacy mechanism in human agency. *Am. Psychol.* 37, 122.  
304 Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. *Psychol.*  
305 *Rev.* 84, 191.
- 306 Bong, C.L., Fraser, K., Oriot, D., 2016. Cognitive Load and Stress in Simulation, in: Grant,  
307 V.J., Cheng, A. (Eds.), *Comprehensive Healthcare Simulation: Pediatrics,*  
308 *Comprehensive Healthcare Simulation.* Springer International Publishing, Cham, pp.  
309 3–17. [https://doi.org/10.1007/978-3-319-24187-6\\_1](https://doi.org/10.1007/978-3-319-24187-6_1)
- 310 Cantrell, M.L., Meyer, S.L., Mosack, V., 2017. Effects of simulation on nursing student  
311 stress: an integrative review. *J. Nurs. Educ.* 56, 139–144.  
312 <https://doi.org/10.3928/01484834-20170222-04>
- 313 Cook, D.A., Brydges, R., Hamstra, S.J., Zendejas, B., Szostek, J.H., Wang, A.T., Hatala, R.,  
314 2012. Comparative effectiveness of technology-enhanced simulation versus other  
315 instructional methods: a systematic review and meta-analysis. *Simul. Healthc.* 7, 308–  
316 320. <https://doi.org/10.1097/SIH.0b013e3182614f95>
- 317 Cook, D.A., Hatala, R., Brydges, R., Zendejas, B., Szostek, J.H., Wang, A.T., Hamstra, S.J.,  
318 2011. Technology-enhanced simulation for health professions education: a systematic  
319 review and meta-analysis. *Jama* 306, 978–988.  
320 <https://doi.org/10.1001/jama.2011.1234>
- 321 El Khamali, R., Mouaci, A., Valera, S., Cano-Chervel, M., Pinglis, C., Sanz, C., D’anna, F.,  
322 2018. Effects of a multimodal program including simulation on job strain among  
323 nurses working in intensive care units: a randomized clinical trial. *Jama* 320, 1988–  
324 1997. <https://doi.org/10.1001/jama.2018.14284>
- 325 Eppich, W., Cheng, A., 2015. Promoting Excellence and Reflective Learning in Simulation  
326 (PEARLS): Development and Rationale for a Blended Approach to Health Care  
327 Simulation Debriefing. *Simul. Healthc. J. Soc. Simul. Healthc.* 10, 106–115.  
328 <https://doi.org/10.1097/SIH.0000000000000072>
- 329 Ericsson, K.A., 2004. Deliberate Practice and the Acquisition and Maintenance of Expert  
330 Performance in Medicine and Related Domains: *Acad. Med.* 79, S70–S81.  
331 <https://doi.org/10.1097/00001888-200410001-00022>
- 332 Geeraerts, T., Roulleau, P., Cheisson, G., Marhar, F., Aidan, K., Lallali, K., Leguen, M.,  
333 Schnell, D., Trabold, F., Fauquet-Alekhine, P., Duranteau, J., Benhamou, D., 2017.  
334 Physiological and self-assessed psychological stress induced by a high fidelity  
335 simulation course among third year anesthesia and critical care residents: An  
336 observational study. *Anaesth. Crit. Care Pain Med.* 36, 403–406.  
337 <https://doi.org/10.1016/j.accpm.2017.06.002>
- 338 Hamill, C., 1995. The phenomenon of stress as perceived by Project 2000 student nurses: a  
339 case study. *J. Adv. Nurs.* 21, 528–536. [https://doi.org/10.1111/j.1365-  
340 2648.1995.tb02737.x](https://doi.org/10.1111/j.1365-2648.1995.tb02737.x)
- 341 Judd, B.K., Currie, J., Dodds, K.L., Fethney, J., Gordon, C.J., 2019. Registered nurses  
342 psychophysiological stress and confidence during high-fidelity emergency simulation:  
343 Effects on performance. *Nurse Educ. Today* 78, 44–49.  
344 <https://doi.org/10.1016/j.nedt.2019.04.005>
- 345 Kaddoura, M.A., 2010. New graduate nurses’ perceptions of the effects of clinical simulation  
346 on their critical thinking, learning, and confidence. *J. Contin. Educ. Nurs.* 41, 506–  
347 516. <https://doi.org/10.3928/00220124-20100701-02>
- 348 Karvounides, D., Simpson, M., P., D., H., W., Khan, A., K., J.W., R. Hainsworth, S., K.,  
349 2016. Three studies supporting the initial validation of the stress numerical rating  
350 scale-11 (Stress NRS-11): A single item measure of momentary stress for adolescents  
351 and adults. *Pediatr. Dimens.* 1, 105–109. <https://doi.org/10.15761/PD.1000124>

- 352 Labrague, L.J., McEnroe-Petite, D.M., Gloe, D., Thomas, L., Papathanasiou, I.V., Tsaras, K.,  
 353 2017. A literature review on stress and coping strategies in nursing students. *J Ment*  
 354 *Health* 26, 471–480. <https://doi.org/10.1080/09638237.2016.1244721>
- 355 Lazarus, R.S., Folkman, S., 1984. *Stress, Appraisal, and Coping*. Springer Publishing  
 356 Company.
- 357 LeBlanc, V.R., MacDonald, R.D., McArthur, B., King, K., Lepine, T., 2005. Paramedic  
 358 performance in calculating drug dosages following stressful scenarios in a human  
 359 patient simulator. *Prehosp. Emerg. Care* 9, 439–444.  
 360 <https://doi.org/10.1080/10903120500255255>
- 361 Lees, T., Lal, S., 2017. Stress and its Impact on the Neurocognitive Performance of Australian  
 362 Nurses: Stress and Cognition in Nurses. *Stress Health* 33, 45–54.  
 363 <https://doi.org/10.1002/smi.2672>
- 364 Lorient, P., Sijelmassi, J., Granry, J.-C., 2018. La simulation dans le domaine de la santé: une  
 365 méthode pour renforcer le sentiment d'efficacité personnelle. Éditions Vuibert.
- 366 Maaløe, R., La Cour, M., Hansen, A., Hansen, E.G., Hansen, M., Spangsborg, N.L.M.,  
 367 Pedersen, T., 2006. Scrutinizing incident reporting in anaesthesia: why is an incident  
 368 perceived as critical? *Acta Anaesthesiol. Scand.* 50, 1005–1013.  
 369 <https://doi.org/10.1111/j.1399-6576.2006.01092.x>
- 370 McCaughey, C.S., Traynor, M.K., 2010. The role of simulation in nurse education. *Nurse*  
 371 *Educ. Today* 30, 827–832. <https://doi.org/10.1016/j.nedt.2010.03.005>
- 372 Nehring, W.M., Lashley, F.R., 2009. Nursing simulation: A review of the past 40 years.  
 373 *Simul. Gaming* 40, 528–552. <https://doi.org/10.1177/1046878109332282>
- 374 Neill, M.A., Wotton, K., 2011. High-Fidelity Simulation Debriefing in Nursing Education: A  
 375 Literature Review. *Clin. Simul. Nurs.* 7, e161–e168.  
 376 <https://doi.org/10.1016/j.ecns.2011.02.001>
- 377 Nestel, D., 2017. Ten years of simulation in healthcare: a thematic analysis of editorials.  
 378 *Simul. Healthc.* 12, 326–331. <https://doi.org/10.1097/SIH.0000000000000230>
- 379 Oh, H.-K., Han, Y.I., 2011. Effects of simulation-based training on stress and self-efficacy in  
 380 nursing students. *J Korean Soc Sch Health* 24, 33–40.
- 381 Pagana, K.D., 1988. Stresses and threats reported by baccalaureate students in relation to an  
 382 initial clinical experience. *J. Nurs. Educ.* 27, 418–424. <https://doi.org/10.3928/0148-4834-19881101-09>
- 384 Regehr, C., LeBlanc, V., Jelley, R.B., Barath, I., Daciuk, J., 2007. Previous trauma exposure  
 385 and PTSD symptoms as predictors of subjective and biological response to stress. *Can.*  
 386 *J. Psychiatry* 52, 675–683. <https://doi.org/10.1177/070674370705201008>
- 387 Regehr, C., LeBlanc, V.R., Barath, I., Balch, J., Birze, A., 2013. Predictors of physiological  
 388 stress and psychological distress in police communicators. *Police Pract. Res.* 14, 451–  
 389 463. <https://doi.org/10.1177/070674370705201008>
- 390 Rosen, K., 2008. The history of medical simulation. *J. Crit. Care* 23, 157–166.  
 391 <https://doi.org/10.1016/j.jcrc.2007.12.004>
- 392 Rothgeb, M.K., 2008. Creating a Nursing Simulation Laboratory: A Literature Review. *J.*  
 393 *Nurs. Educ.* 47, 489–494. <https://doi.org/10.3928/01484834-20081101-06>
- 394 Rudolph, J.W., Simon, R., Rivard, P., Dufresne, R.L., Raemer, D.B., 2007. Debriefing with  
 395 Good Judgment: Combining Rigorous Feedback with Genuine Inquiry. *Anesthesiol.*  
 396 *Clin.* 25, 361–376. <https://doi.org/10.1016/j.anclin.2007.03.007>
- 397 Savoldelli, G.L., Naik, V.N., Park, J., Joo, H.S., Chow, R., Hamstra, S.J., 2006. Value of  
 398 Debriefing during Simulated Crisis Management Oral versus Video-assisted Oral  
 399 Feedback. *Anesthesiol. J. Am. Soc. Anesthesiol.* 105, 279–285.  
 400 <https://doi.org/10.1097/00000542-200608000-00010>
- 401 Schön, D.A., 1983. *The reflective practitioner: how professionals think in action*. Basic  
 402 Books, New York.

- 403 Tomaka, J., Blascovich, J., Kelsey, R.M., Leitten, C.L., 1993. Subjective, physiological, and  
404 behavioral effects of threat and challenge appraisal. *J. Pers. Soc. Psychol.* 65, 248.  
405 <https://doi.org/10.1037/0022-3514.65.2.248>
- 406 Vine, S.J., Uiga, L., Lavric, A., Moore, L.J., Tsaneva-Atanasova, K., Wilson, M.R., 2015.  
407 Individual reactions to stress predict performance during a critical aviation incident.  
408 *Anxiety Stress Coping* 28, 467–477. <https://doi.org/10.1080/10615806.2014.986722>
- 409 Waxman, K.T., 2010. The Development of Evidence-Based Clinical Simulation Scenarios:  
410 Guidelines for Nurse Educators. *J. Nurs. Educ.* 49, 29–35.  
411 <https://doi.org/10.3928/01484834-20090916-07>
- 412 Wickers, M.P., 2010. Establishing the Climate for a Successful Debriefing. *Clin. Simul. Nurs.*  
413 6, e83–e86. <https://doi.org/10.1016/j.ecns.2009.06.003>  
414

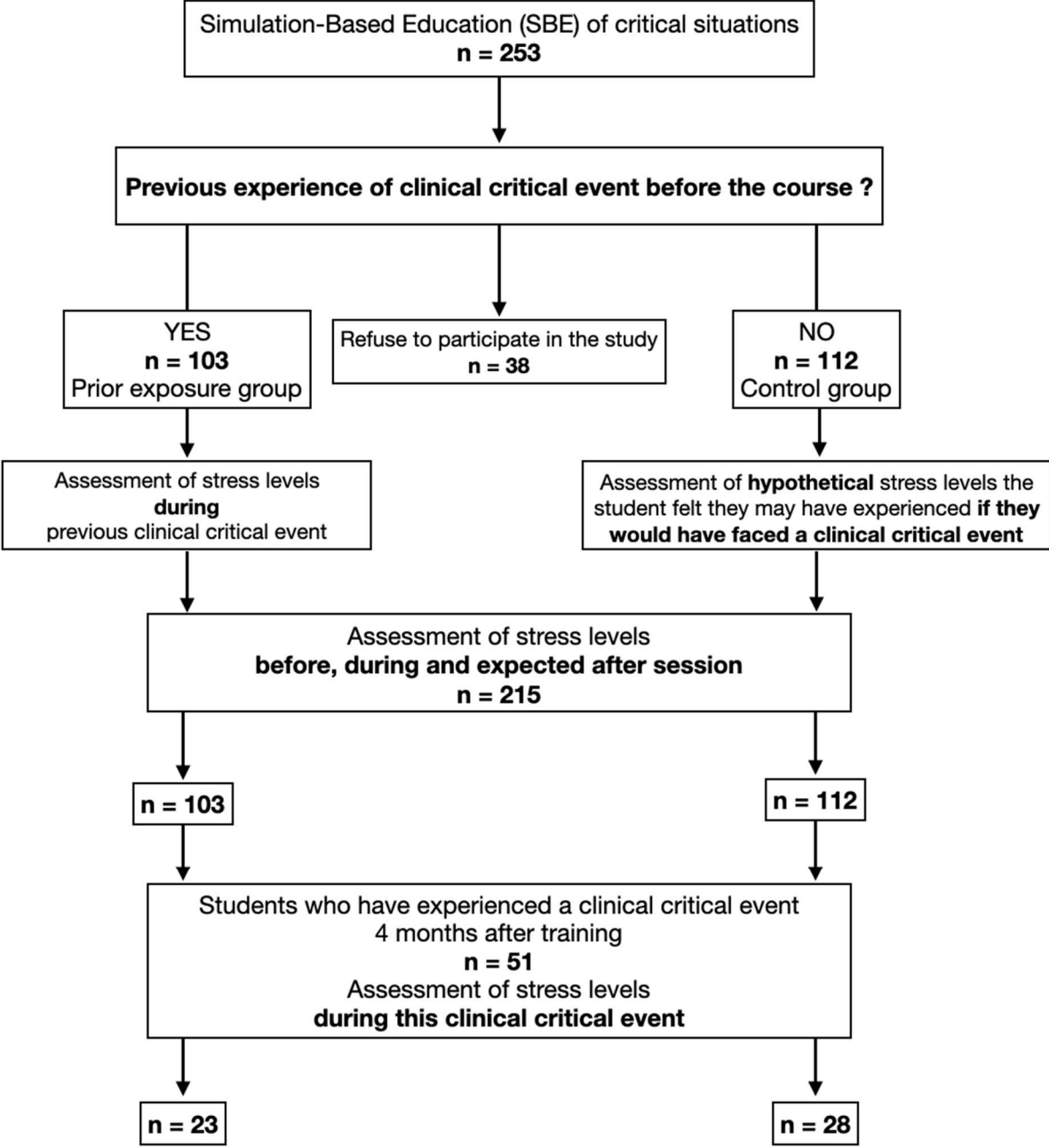
415 **Figure Legends**

416 Figure 1: Flow chart of the study

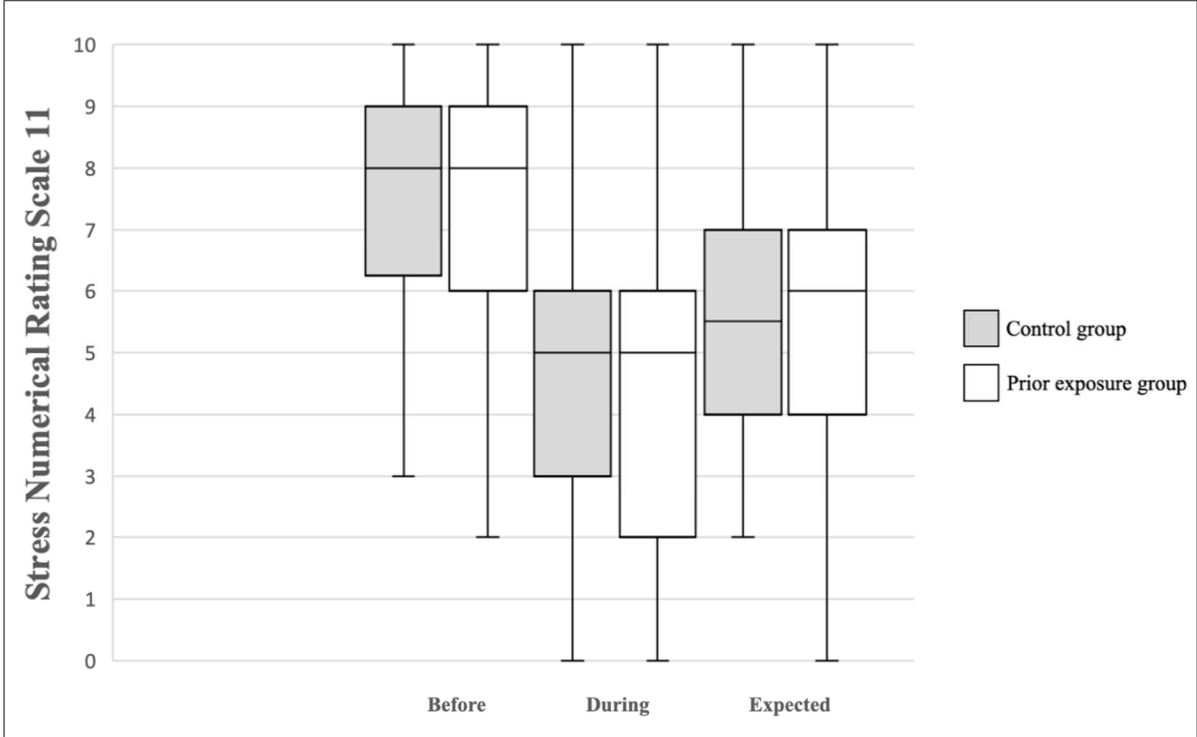
417 Figure 2: Perceived stress levels before, during and expected after the simulation-based  
418 education.

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

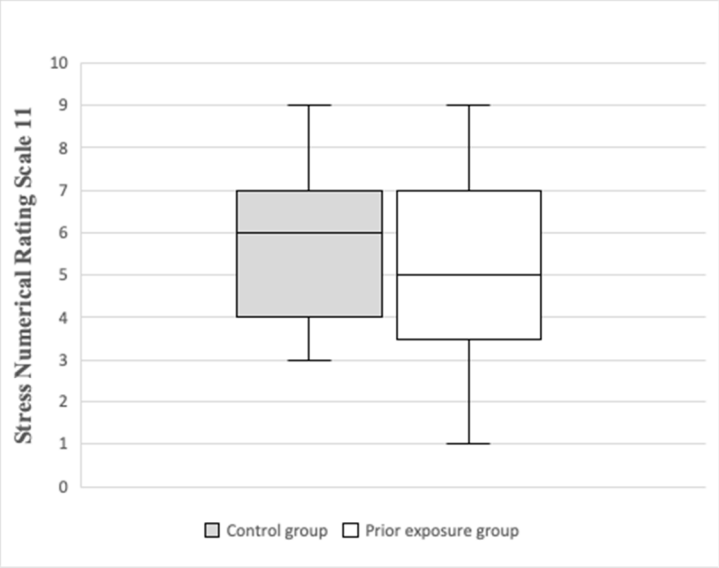
Figure 1: Flow chart of the study



**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.**





**Table 1: Simulation scenarios**

Scenario number	Main theme	Type of simulation	Educational goals	
			Technical skills	Non-technical skills
1	Chest pain	Standardized patient	X	<ul style="list-style-type: none"> <li>- Clinical reasoning</li> <li>- Examination of the patient</li> <li>- Transmission of patient reports to the emergency call reception and dispatch center with SAED</li> </ul>
2	Cardiac arrest	Full-scale simulation with low-fidelity mannequin	<ul style="list-style-type: none"> <li>- CPR: cardiac massage, insufflation with BVM</li> <li>- Inserting a peripheral IV</li> <li>- Adrenaline preparation</li> </ul>	<ul style="list-style-type: none"> <li>- Clinical reasoning</li> <li>- Calling for help</li> <li>- Transmission of patient reports to the emergency call reception and dispatch center with SAED</li> </ul>
3	Hypoglycemia	Standardized patient	<ul style="list-style-type: none"> <li>- Installation adapted to the state of consciousness</li> <li>- Inserting an IV</li> <li>- Preparation of glucose 30%</li> </ul>	<ul style="list-style-type: none"> <li>- Clinical reasoning</li> <li>- Transmission of patient reports to the doctor with SAED</li> <li>- Application of a nursing emergency care protocol</li> <li>- Traceability in the care record</li> </ul>
4	Lower limb trauma	Standardized patient	<ul style="list-style-type: none"> <li>- Immobilization</li> <li>- Inserting an IV</li> <li>- Preparation of analgesics</li> </ul>	<ul style="list-style-type: none"> <li>- Clinical reasoning</li> <li>- Transmission of patient reports to the doctor with SAED</li> <li>- Application of a nursing emergency care protocol</li> <li>- Traceability in the care record</li> </ul>

CPR: CardioPulmonary Resuscitation

BVM: Bag Valve Mask

IV: IntraVenous

SAED: Situation, Antecedents, Evaluation, Demand