# The impact of stressors on the learning outcome of high-fidelity patient simulation in undergraduate medical students

**Nachiappan Murugavadigal, FRCS, Bikramjit Pal, MS, Aung Win Thein, FRCS Ed, Htoo Htoo Kyaw Soe, PhD, Sudipta Pal, MSc**

Melaka-Manipal Medical College, Jalan Batu Hampar, Bukit Baru, Melaka, Malaysia

## ABSTRACT

**Introduction: Simulation of the clinical setting incorporates an educational approach connecting a learner to a particular environment of learning. Undergraduate students in the health sector experience anxiety during simulation that influences their performance which ultimately affects their learning outcome. This study attempts to correlate the impact of stressors on learning outcome of high-fidelity patient simulation (HFPS) in undergraduate medical education.**

**Objective: This research is to analyze the impact of stressors and its relevance on the learning outcome of HFPS as a teaching-learning tool for the management of emergency surgical conditions including trauma.**

**Materials and Methods: This study is a Quasi-experimental time series design. A total number of 347 final-year undergraduate (MBBS) students of Melaka-Manipal Medical College, Malaysia. They were grouped and assessed individually by pre-test and post-tests on their knowledge, performance and associated stressor scores. The one-way repeated measure of Analysis of Variance (ANOVA) was used to determine the statistically significant differences in total score at pre-test simulation and post-test-simulation sessions. Friedman test was used for assessment of individual components of stressors. Pre-test and post-tests scores were compared to note progress in confidence and stress reduction. P value <0.001 was considered statistically significant.**

**Results: ANOVA with Bonferroni post hoc analysis showed a statistically significant (p <0.001) difference in stressor score over time. The drop-in stress was significant initially but flattened out later.**

**Conclusion: Stress significantly decreased as the students were exposed to more sessions of HFPS which ultimately translated into better learning outcome.**

**KEY WORDS:**
*High fidelity patient simulation, stressors in medical education, simulation in medical education, stress in simulation*

## INTRODUCTION

Simulation of the clinical setting is not a technology but a technique which replaces or augments real experiences with guided experiences to elicis or imitate substantial aspects of the real world in a fully interactive manner.[1] Simulation is an all-inclusive term that encompasses interactive as well as immersive activity due to recreation of a part or whole of a clinical experience without putting patients to any antecedent risks.[2] It is now well recognized that high-fidelity patient simulation (HFPS) encourages learning if it is facilitated in appropriate settings.[3] A facilitated simulation experience stimulates reflective thinking and allows a provision for feedback. Learners are encouraged to explore emotions, question and reflect by providing a suitable feedback.[4] Medical simulators are extensively used to teach diagnostic as well as therapeutic procedures to develop medical concepts that help in decision making.[5] It helps to add an emotional component to the experience for most of the students that helps in committing new information into memory.[6] Simulation as a teaching tool can be a profound stressor for the students. The simulation environment created by high-fidelity mannequins and electronic devices can evoke stress among students which may affect the psychological and psychomotor aspects of learning.[7] The interference of the stressors in the learning process may challenge the effectiveness of simulation as an educational tool for undergraduate students. The impact of anxiety may influence their performance that ultimately lead to poor learning outcome.[8] Simulation-based medical education (SBME) may give rise to stress amongst healthcare professionals. This stress, if in excess, may affect learning and skills-performance due to cognitive overload.[9] An environment of safety is a pre-requisite for the simulation participants as they find the experience is often overwhelmingly stressful and are worried about judgment from their peers and facilitators.[10] The most likely stressors are environmental, technological and human factors.[11] Simulation sessions are usually conducted in stress free environment when compared to the clinical settings in real life, and therefore, can be used as a stress reduction strategy to overcome the anxiety in real clinical setting.[12] The understanding of students by educators about stress accompanying simulation is of paramount importance as this will ensure them to provide more effective educational support during the simulation sessions which ultimately lead

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*Corresponding Author: Dr. Nachiappan Murugavadigal*
*Email: nachiappan.murugavadigal@manipal.edu.my*

to better learning outcomes.[13] Research is required to formulate specific interventions capable of reducing stress level of students during simulation to evolve a standard procedure for best practices in preparing the students to cope with the anxiety in the clinical setting.[14]

## MATERIALS AND METHODS

*Type of study and General Design*

This is a Quasi-experimental time series study with pretest-posttest intervention.

*Eligibility criteria for participants*

*Inclusion criteria:* Both male and female undergraduate (MBBS) final year students of Melaka-Manipal Medical College (MMMC), Malaysia were recruited during their surgical posting after obtaining informed consent.

*Exclusion criteria:* Students who declined for consent to participate in this study.

*Study population*

The number of students who had completed the training course was 92.53% (347 final year students of a total of 375). The drop-out number was 26 (6.93 %). Two students (0.54 %) declined to participate in the study. The study was conducted in Clinical Skills and Simulation Lab of MMMC from October 2015 to September 2017. METIman Pre-Hospital HI-Fidelity Simulator (Serial number: MMP-0418; CAE Healthcare, USA) was used for the simulation-based learning sessions. It is a fully wireless and tether-less, adult High Fidelity Simulator (HFS) with modelled physiology.

A pilot study involving 50 students was conducted to explore the time management, feasibility, acceptability and validation of the questionnaires. The students were divided into groups. Each group consisted of twelve to fifteen students who were further divided into three teams of four to five students each to participate in the simulation sessions.

A briefing on the course, learning objectives, simulation sessions and expected learning outcomes was given. The expected learning outcome of HFPS session was improvement in knowledge and skills with reduction of stress by engaging the students in repeated HFPS sessions. A theoretical briefing in the form of interactive lecture was given to the whole group on the management of emergency surgical conditions like hypovolemic shock, tension pneumothorax and head injury, as per Advanced Trauma Life Support (ATLS) was given to all participants. The three teams in the group were assigned three different scenarios which were chosen randomly from the conditions stated above. Each team then participated in a trauma simulation session. The allocated time for each simulation session was as follows: Pre-brief (10 minutes), Simulation (20 minutes) and Debriefing (20 minutes). During the pre-brief, the participants were made aware about the confidentiality of the high fidelity simulation sessions and the ethical issues involved and were shown the environment and the functions of the simulator to avoid stress caused by ignorance of the technology used. The students were assured that the program was not part of the evaluation process for the surgical curriculum. After completion of each session, the teams were debriefed in order to achieve the learning outcomes. The same team then participated in the simulation of the same scenario after one week (second simulation session) and at three/four weeks (third simulation session), followed by final debriefing (See Appendix I). The progress of stress reduction of each participant was assessed individually. A standardized five-point Likert scale questionnaire (Pre-test) was designed to collect the initial background knowledge and stressor assessment of the students just before the interactive lecture session on the first day of the training course (See Appendix II). The same questionnaire was repeated at Post-tests after every simulation session. All the participants were assessed four times (Stressor assessment at HFPS-based learning on management of trauma: Pre-test simulation assessment, Stressor assessment at HFPS-based learning on management of trauma: Post-test simulation assessment I, Stressor assessment at HFPS-based learning on management of trauma: Post-test simulation assessment II and Stressor assessment at HFPS-based learning on management of trauma: Post-test simulation assessment III). The stressor questionnaire contained 13 items that were used to compare the progress in confidence and stress reduction. It was an ordinal scale (1 to 5) used by the participants to rate the degree of stress: no stress (1), low stress (2), moderate stress (3), high stress (4) and maximum stress (5). We had used a validated stressor questionnaire developed by Dinker R. Pai et al.[15] that was reviewed and adapted for this research study. The stress factors that had been identified by the students during the simulation sessions in the pilot study done by the said authors, were incorporated in the questionnaire. The content validation was reviewed for its suitability, clarity and relevance by six medical education experts of at MMMC to test its applicability at the simulation sessions. They were also requested to suggest other items that they felt needed to be included, if necessary. There were no additional suggestions from the experts. The final questionnaire was then prepared for use based on the reviewers' comments and the feedback from the pilot study. We checked the content and the face validity of the stressor assessment. For internal consistency, we calculated Cronbach's alpha coefficient of the stressor assessment. The Cronbach's alpha coefficient for stressor assessment questionnaire was 0.846.

*Data Analysis*

Microsoft Excel was used for data entry and SPSS software (SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.) for data analysis. Descriptive statistics such as frequency and percentage for categorical data; mean and standard deviation for total score of applied knowledge, psychomotor skills, simulation assessment and stressor assessment were calculated. Median, 1st quartile (Q1) and 3rd quartile (Q3) were calculated for each individual item of stressor assessment. The one-way repeated measure ANOVA with Bonferroni post hoc analysis was used to determine the statistically significant difference in simulation assessment (total score) and stressor assessment (total score). Friedman test was used to determine the statistically significant difference in individual item of stressor assessment. P-value $<0.001$ was considered to be statistically significant.

**Table I: Stressor assessment (Repeated measure ANOVA) at HFPS-based learning on management of trauma: pre-test simulation assessment, post-test simulation assessment I, post-test simulation assessment II and post-test simulation assessment III (total score).**

| Assessment | Total score: Mean (SD) | P value |
|---|---|---|
| Pre-test simulation assessment | 27.41 (7.32) | |
| Post-test simulation assessment I | 25.98 (8.16) | |
| Post-test simulation assessment II | 24.92 (8.71) | < 0.001* |
| Post-test simulation assessment III | 24.54 (9.59) | * Significant |

**Table II: Pairwise comparison (total score) with Bonferroni adjustment**

| Assessment | | Stressor Score (MD) – (95% CI) | P value |
|---|---|---|---|
| Pre-sim | Post-sim I | 1.43 (0.19, 2.66) | 0.013 |
| | Post-sim II | 2.49 (1.17, 3.80) | < 0.001* |
| | Post-sim III | 2.87 (1.38, 4.36) | < 0.001* |
| Post-sim I | Post-sim II | 1.06 (-0.13, 2.25) | 0.114 |
| | Post-sim III | 1.44 (0.15, 2.73) | 0.019 |
| Post-sim II | Post-sim III | 0.38 (-0.82, 1.6) | 0.999 |

* Significant

**Table III: Friedman test of Stressor assessment (individual items)**

| Stressor Assessment of Individual Item (Friedman test) | Pre-Sim | Post-Sim I | Post-Sim II | Post-Sim III | P value |
|---|---|---|---|---|---|
| | Median (Q1, Q3) | | | | |
| 1. Difficulty in understanding the content | 3.0 (3.0, 4.0) | 3.0 (2.5, 4.0) | 3.0 (2.0, 3.0) | 3.0 (2.0, 4.0) | 0.127 |
| 2. Need to do well (self-expectation) | 4.0 (3.0, 4.0) | 4.0 (3.0, 4.0) | 3.0 (3.0, 4.0) | 3.0 (3.0, 4.0) | < 0.001* |
| 3. Competition due to working in a team | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 3.0) | 3.0 (2.0, 3.0) | 0.001* |
| 4. Shortage of time during training session | 3.0 (3.0, 4.0) | 3.0 (3.0, 4.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | < 0.001* |
| 5. Feeling of incompetence in managing patient | 4.0 (3.0, 4.0) | 4.0 (3.0, 4.0) | 3.0 (3.0, 4.0) | 3.0 (3.0, 4.0) | < 0.001* |
| 6. Death of the simulated patient | 4.0 (3.0, 4.5) | 4.0 (3.0, 5.0) | 4.0 (3.0, 4.0) | 4.0 (3.0, 4.0) | 0.001* |
| 7. Conflict with other students | 3.0 (2.0, 3.0) | 2.0 (2.0, 3.0) | 2.0 (2.0, 3.0) | 2.0 (2.0, 3.0) | < 0.001* |
| 8. Need to participate in scenario | 3.0 (3.0, 4.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 0.016 |
| 9. Participation in debriefing | 3.0 (2.0, 3.0) | 3.0 (2.0, 3.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 3.0) | 0.009 |
| 10. Not knowing my role in the team | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | < 0.001* |
| 11. Lack of appreciation to my contribution in the team | 4.0 (2.0, 4.0) | 3.0 (2.0, 3.0) | 3.0 (2.0, 3.0) | 3.0 (2.0, 3.0) | < 0.001* |
| 12. Stress during simulation as instructor is observing | 4.0 (3.0, 4.0) | 4.0 (3.0, 4.0) | 3.0 (3.0, 4.0) | 3.0 (3.0, 4.0) | < 0.001* |
| 13. Stress during simulation as fellow classmates are observing | 3.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 3.0 (2.0, 3.0) | 3.0 (2.0, 3.0) | 0.001* |

* Significant

**Table IV showes significant enhancement of knowledge with subsequent simulation sessions.**
**Table IV: Knowledge assessment (total score) at pre-test, post-test simulation I, post-test simulation II and post-test simulation III**

| Assessment | Knowledge Assessment Total score Mean (SD) | P value |
|---|---|---|
| Pre-test simulation | 7.99 (3.28) | <0.001* |
| Post-test simulation I | 11.66 (2.92) | |
| Post-test simulation II | 12.52 (2.89) | |
| Post-test simulation III | 13.33 (2.84) | |

One-way repeated measure ANOVA; * Significant.

**Table V showes statistically significant enhancement of skills with subsequent simulation sessions.**
**Table V: Simulation skills assessment at pre-test simulation, post-test simulation I, post-test simulation II and post-test simulation III (total score).**

| Assessment | Simulation Assessment Total Score Mean (SD) | P value |
|---|---|---|
| Pre-test simulation | 30.12 (5.19) | <0.001* |
| Post-test simulation I | 52.75 (7.59) | |
| Post-test simulation II | 52.19 (7.06) | |
| Post-test simulation III | 52.35 (7.57) | |

One-way repeated measure ANOVA; * Significant.

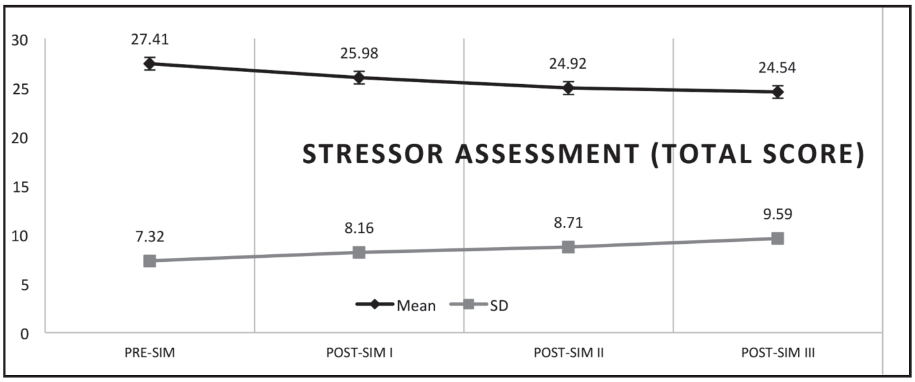


**Fig. 1:** Stressor Assessment (Total Score) of HFPS-based learning on management of trauma: pre-test simulation assessment (PRE-SIM), post-test simulation assessment I (POST-SIM I), post-test simulation assessment II (POST-SIM II) and post-test simulation assessment III (POST-SIM III).

## RESULTS

A one-way repeated measures ANOVA with Bonferroni *post hoc* analysis was conducted to determine whether there was a statistically significant difference in stressor score over time during simulation sessions. Table I shows the total stressor scores (Mean and SD) at pre-test simulation assessment, post-test simulation assessment I, post-test simulation assessment II and post-test simulation assessment III. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $\chi^2(5) = 23.070$, $p < 0.001$. Greenhouse & Geisser was used to correct the one-way repeated measures ANOVA. The total stressor score of simulation assessment was statistically significant over time, $F$ (2.824, 762.61) = 13.983, $p < 0.001$. Total stressor score had decreased from 27.41 (SD 8.16) at pre-test simulation to 25.98 (SD 8.16) at post-test simulation I, 24.92 (SD 8.71) at post-test simulation II and 24.54 (SD 9.59) at post-test simulation III.

*Post hoc* analysis with a Bonferroni adjustment revealed that pre-test simulation assessment score was significantly different from post-test simulation assessments II and III but there were no significant differences between the post-test simulation assessments as shown in Table II.

Friedman test of stressor assessment for individual items showed significant difference of stressor scores over time in item numbers two to seven and 10 to 13. There is a significant drop in scores of stressor elements when the participants were subjected to more sessions of simulations [See Table III].

## DISCUSSION

Stress is not uncommon in critical scenarios in the clinical environment that affects clinical judgement and patient outcomes. Presently, there is limited data about methods that have been used concomitantly with simulation training programs for healthcare professionals that address stress management.[16] The simulators used in healthcare practice are important tools in eliciting a physician's understanding and use of best practices for management of patient complications with suitable use of instruments and tools, leading to appropriate competence in performing procedures.[17] Sometimes simulation sessions are stressful and this experience can be used as an effective tool in preparing the students for stressful situations in their career. The identification of possible causes of stress during simulation may indicate the changes that has to be made.[18] There is greater possibility for improved performance and better learning outcomes in simulation as a result of better understanding of the situation if the cognitive load is appropriate with moderate level of stress. But excessive stress leads to impaired performance due to cognitive overload, attentional narrowing and distractibility. Simulation Based Medical Education (SBME) has all the components for a stressful experience as it is a novel method of teaching, which may be challenging as the sessions sometimes impart a sense of unpredictability and lack of control.[19] Simulation may be useful in the emotional preparation of future healthcare professionals by exposing them to practice their skills in safe environments where stress factors can be modulated to have better learning outcome.[20] High-fidelity patient simulator may induce significant stress in students, which may affect their performance, and most likely reproduce to the stress experienced by physicians and nurses when they are subjected to a real clinical environment.[11] Our study worked with 13 stressors, which may affect the learning outcomes of high fidelity patient simulation in undergraduate medical education. All these stressors showed a significant drop in scores with repeated simulation sessions ($p < 0.001$) except in the category of "Death of a simulated patient" where the stress was unabated among the participants in all simulation sessions. MacDougall, Martin, McCallam and Grogan (2013) reported in their study found that there was no significant difference between the pre-simulation session and post-simulation session scores and at the same time students did not show a decrease in confidence following the session.[21] Our study revealed that there is statistically significant ($p < 0.001$) drop in stress when pre-simulation stressor scores were compared with post-simulation scores. The drop seen in stress was significant initially but flattened out later. This is likely due to the adaptability of students to the situation in latter simulation sessions. This is similar to the findings by Lasater who reported that stress tends to decrease with continued practice.[22] Similarly, the study by Ghazali DA, Ragot S, Oriot D (2016) revealed that stress declined over time with the repetition of simulation sessions.[23] Fauquet-Alekhine P. et al. (2014) also observed that progressive simulation sessions helped to reduce stress of the students.[24] But a study by Geeraerts et al, reported that simulation-induced stress is high before the session and rises significantly instead of falling during the course, though this stress did not decrease the performance.[25] Similar findings were observed in a study by Alhedaithy et al. (2018) which showed that there was significant increase of stress in all phases of simulation without any appreciable impact on performance.[26] The same kind of continuous emotional activity was observed in the students during surgical simulation sessions in a study done by Phitayakorn, Minehart, Pian-Smith, Hemingway and Petrusa.[27] In our study, we found that the total score of knowledge assessment had significantly improved in all three post-test simulations compared to pre-test simulation. Similarly, the total score of skills assessments had shown statistically significant improvement in all three post-test simulations compared to pre-test simulation. We found that there was a good correlation between improvement of both knowledge and skills with reduction in stress. This finding is consistent with the study done by Habibah Elias, Wong Siew Ping, Maria Chong Abdullah.[28] The importance of stressors is well established in both technical and human aspects of simulation, such as working on mannequins, while being observed by their faculty and fellow colleagues, and there is performance anxiety. Mary Louis Cato, in her study, had shown that the possibility of making a mistake during simulation sessions led to maximum stress followed by being observed on camera and performance in front of faculty and friends.[11] The same was observed in our study where the students perceived very high stress when the faculty and colleagues were present during the simulation sessions. The presence of peers during simulation sessions may result in increased stress.[26] Boostel Radamés et al. (2018) study also showed that the participants in high fidelity patient simulation had increased perception of stress related to interpersonal relationships with patients, faculty and colleagues.[29] In study by Cato[11] the lowest score was noted in “working with a team” though it produces moderate stress among the students in our study. The highest stressor score in our study was noted in “Death of the simulated patient”, which is similar to the finding by Lasater (2007) who reported that students experienced maximum stress during simulation in relation to the anticipation of an unexpected event.[22] “Seeing a patient die” is significantly more stressful.[29] The next two high stressor scores in our study were “Feeling of incompetence in managing patient” and “Need to do well (self-expectation)”. “Competition due to working in a team” showed moderate stressor score in comparison to low score in Cato’s study.[11] The stressor score in the category “Participation in debriefing” showed moderate level all throughout the simulation training course.

For an optimum skills learning and transfer of knowledge and skills from a simulated situation to clinical situations, an orderly ramped up sequence of acquiring technical skills, clinical decision making as well as stress management techniques are necessary.[12]

Limitations of this study: The study was conducted on the information provided by students. There is a chance of selection bias due to volunteer nature of inclusion criteria. The participants' interpretation of the questions and subjective nature in reporting their emotions may result in reporting bias. The general feeling of stress may be associated with other personal attributes which were not measured in this study. The study dealt with some variables like simulation course implementation, curricular integration, faculty expertise and student characteristics which could have influenced the findings. Lastly, this was a single center study and had only included the final year medical students and as such the findings may not be applicable to other settings.

## CONCLUSION

High-fidelity patient simulation training programs complement medical education in patient care settings. There is emergence of two contrasting views which revealed the current lack of understanding regarding the effect of stressors on performance and learning outcome in a high-fidelity patient simulation setting. The stressors in simulation affect learners physiologically and psychologically, which lead to either improved or deteriorating clinical performance. Creating an optimal environment of safety in simulation space, equipment and expectations, undoubtedly helps to decrease stress. This study explored how student anxiety during simulation affected learning. The quantitative data obtained in this study were valuable in identifying the student perception to different elements of the high fidelity simulation experience and their adaptability to the situation. Simulation-based medical education may be helpful in preparing students to cope and respond more satisfactorily to stressful events in real clinical practice. Stress reduction by repeated exposure ultimately translated into better learning outcome. Students' favorable perception on high fidelity patient simulation in this study had shown that it is a promising teaching-learning tool that could be included in undergraduate medical curriculum.

## ETHICAL CONSIDERATION

Ethical approval was obtained from the Ethical Committee / IRB of MMMC. Informed consent was taken from all the participants. All information about the participants was kept confidential.

## ACKNOWLEDGEMENT

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## CONFLICT OF INTEREST

The researchers had not received any funding or benefits from industry or elsewhere to conduct this study and had no conflicts of interest.

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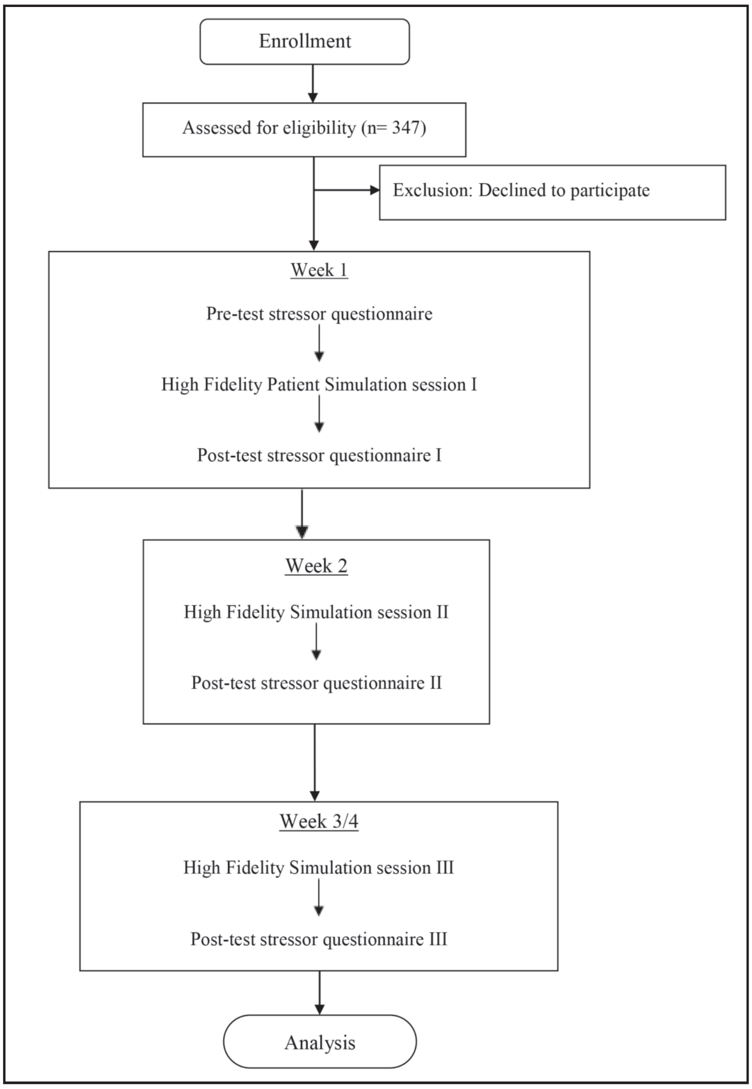
**Appendix I: Flow chart**




**Appendix II: Sample of Pre-test stressor questionnaire.**

**Melaka-Manipal Medical College**
Batch & Group: …………...
Team: 1 2 3

Date:
Index number: B31GK

**STRESSOR ASSESSMENT AT HFPS-BASED LEARNING ON MANAGEMENT OF TRAUMA: PRE-TEST SIMULATION ASSESSMENT**

| SI No. | Tick the appropriate column to indicate the level of Stress that you think you are likely to experience in each of the following: | How do you rate it? | | | | |
|---|---|---|---|---|---|---|
| | | No Stress (1) | Low (2) | Moderate (3) | High (4) | Maximum Stress (5) |
| SA1-1 | Difficulty in understanding the content | | | | | |
| SA1-2 | Need to do well (self-expectation) | | | | | |
| SA1-3 | Competition due to working in a team | | | | | |
| SA1-4 | Shortage of time during training session | | | | | |
| SA1-5 | Feeling of incompetence in managing patient | | | | | |
| SA1-6 | Death of the simulated patient | | | | | |
| SA1-7 | Conflict with other students | | | | | |
| SA1-8 | Need to participate in scenario | | | | | |
| SA1-9 | Participation in debriefing | | | | | |
| SA1-10 | Not knowing my role in the team | | | | | |
| SA1-11 | Lack of appreciation to my contribution in the team | | | | | |
| SA1-12 | Stress during simulation as instructor is observing | | | | | |
| SA1-13 | Stress during simulation as fellow classmates are observing | | | | | |