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RESEARCH ARTICLE

Immersive Simulation and Paramedicine Students' Situational Awareness: A Mixed-Methods Pilot Study

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ABSTRACT

Background: Situational awareness involves the ability to recognise and interpret environmental cues and utilise this to predict future events. It is an important factor in the minimisation of human error in many settings, including healthcare. It is especially relevant within paramedic practice where the situation may be highly dynamic. Simulation-based education is increasingly used within paramedicine education and has been demonstrated as effective for the development of situational awareness in healthcare professionals.

Aims: The primary aim of this study was to evaluate the level of situational awareness in undergraduate paramedicine students during an immersive simulation compared to that during a more conventional, non-immersive scenario. A secondary aim was to examine student perceptions of situational awareness, as well as their experiences of the simulations in which they participated.

Methods: Third-year paramedicine students at an Australian university participated in two simulated emergency scenarios; one in an immersive setting, and one in a non-immersive environment. The Situation Awareness Global Assessment Technique was utilised to assess their level of situational awareness at various pre-determined points in each scenario. Subsequently, semi-structured interviews were utilised to examine student perceptions of situational awareness as well as their experiences of the simulations.

Results: Overall, students (n=18) demonstrated lower levels of situational awareness in the immersive simulation compared with the non-immersive simulation. Most errors occurred in the initial stages, within the 'recognition' component of situational awareness. Eight students participated in follow-up interviews, with the majority expressing that the immersive nature of the simulation adversely affected their scenario management. They reported difficulty in recall of basic knowledge, disorganisation of thoughts and clinical approach, and being able to concentrate only on one thing at a time.

Conclusion: Paramedicine students in our study demonstrated lower levels of situational awareness during an immersive simulated scenario compared with a conventional non-immersive setting, particularly in the initial 'recognition' stage of situational awareness. As a lack of situational awareness may contribute to healthcare errors, its assessment and development must be addressed within paramedicine education. The utilisation of immersive simulation in paramedicine curricula may play an important role in this area.

Keywords: Allied Health Personnel, Awareness, Emergency Medical Technicians, Metacognition, Paramedicine, Situational awareness

Introduction

Human error within healthcare contributes substantially to adverse health outcomes. For example, in the United States, healthcare errors are reported to be the third leading cause of hospital inpatient death with estimates of up to 400,000 deaths annually.[1] In Australia, it has been estimated that there may be as many as 18,000 deaths and over 50,000 disabilities per year as a result of medical error.[2] Other researchers estimate that medical error in Australia results in 174 daily preventable deaths.[3] Additionally, non-lethal adverse events maybe 10-20 times more common than those resulting in death.[4] While there is always the potential for human error within healthcare, accurate decision-making can be enhanced by the capacity to correctly recognise and interpret environmental cues and information, and then use these elements to predict probable outcomes.[5] It is a complex cognitive process, and when accomplished, can minimise adverse events caused by human error.[6] This is especially the case in the out-of-hospital environment where conditions may be rapidly changing and clinically challenging.

Situational Awareness

Situational awareness (SA) is the "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future".[6] A low level of SA has been identified as a critical component of accidents caused by human error.[7]

Recognition is the first level of SA (Level 1 SA) and involves awareness and identification of information or cues from your environment. Interpretation (Level 2 SA) involves understanding and integrating all perceived information to generate meaning and determine the relevance of the presented information. The final component of SA is prediction (Level 3 SA) where a thorough understanding of all factors of a situation and the temporal aspects of these factors, such as whether the information is changing and how quickly, enables an individual to determine the probable course of future events.[8] While a high level of SA is a precursor to appropriate decision-making and action, it is important to note that it does not preclude inappropriate decisions and actions, which may be affected by numerous other factors.[8]

The importance of being situationally aware was initially recognised in the operation of combat aircraft in World War I.[6] Since this time, SA has been utilised within many high-stakes fields involving complex cognitive tasks and dynamic environments such as aviation, offshore oil drilling, nuclear power plants, medicine, and the military.[9-13] The consequences of a lack of SA within areas such as these may be serious and potentially life-threatening.[14,15]

Emergency medicine is a high-risk area of healthcare with the potential for human error made more likely by such issues as a high turnover of patients, time constraints, large variety of clinical presentations, multiple distractions, shift work, rapidly changing and evolving situations, and often limited historical and diagnostic information.[16] Within the out-of-hospital setting, paramedicine shares these characteristics, and with it the high potential for human error. In a complex and rapidly changing emergency environment, the huge amounts of information that needs to be understood, processed and acted upon may result in high cognitive loads and a concomitant reduction in SA.[11] It is within such an environment often encountered by paramedics in out-of-hospital emergencies that low levels of SA may lead to deleterious consequences. However, training and repetition may develop the skill of SA and maintain it for high-stakes situations such as resuscitation.[17] One approach to enable the assessment and development of SA for paramedics involves the use of simulation techniques. In addition, Endsley's model of SA has been shown to be the best model to apply within a paramedicine setting.[5]

Simulation

SA assessment and training commonly utilise simulations of high-risk events and situations to measure and develop relevant skills. Simulated scenario exercises aim to portray real-life situations to enable experiential teaching, learning and practice, as well as skills assessment.[18,19] Gaining knowledge, experience and expertise in emergency situations, especially those which occur relatively infrequently, can be challenging for students or professionals. Thus, within healthcare, simulation-based education (SBE) may be used to provide an experience of these occurrences, without risking harm to the patient or the healthcare provider. Various levels of realism (in terms of the physical environment and functional or behavioural requirements), or fidelity, of a scenario may be developed.[20] Immersive simulation psychologically engages the learner as believable and authentic clinical practice. Furthermore, the level of psychological engagement links the students' experiences of the simulation providing a substantial degree of realism and interaction and most closely resembles a realistic clinical environment.[21] Features such as manikins that react in a physiologically appropriate manner to interventions, simulated patients played by highly

trained actors, virtual reality, and surround audio-visual settings have all been employed to enhance the realism of a clinical scenario.[22-25] The World Health Organization has strongly recommended that simulation should be utilised in the education of health professionals, and where resources are available and where appropriate, that simulation is utilised.[26]

Although the literature exploring the relationship between immersive SBE and SA is limited, the former has been reported to improve the latter. A study of paediatric cardiovascular critical care trainees who participated in four immersive simulations of emergency scenarios over two days demonstrated a statistically significant improvement in SA when comparing pre- to post-training. Although SA levels had declined at two months post-intervention, they remained significantly higher than pre-intervention levels.[27] Another study reported on a program of over 40 immersive prehospital critical care simulations across twelve days, delivered to paramedics and physicians. It was determined that SA measured on days nine and ten was significantly higher than that on day four.[28] In addition, a recent systematic review and meta-analysis demonstrated that SBE can more effectively improve SA compared with other interventions, such as workshops and crisis/crew resource management training.[29]

However, despite the importance of SA in potentially hazardous and high-stakes occupations such as paramedicine,[30] research within this field is not well developed. A recently published scoping review demonstrated that the examination of SA within paramedicine is a relatively new endeavour and requires further research to elucidate the details of its relationship to paramedicine and patient safety as well as health outcomes.[31]

Aims

The primary aim of this study was to evaluate the level of SA in third-year undergraduate paramedicine students during an immersive simulation of an emergency situation compared to that demonstrated during a scenario in a non-immersive setting. A secondary aim was to examine student perceptions of the concept of SA as well as their experiences of the simulations in which they participated.

Methods

Design

This study used a mixed-method design to examine the SA of third-year paramedicine students at an Australian university. Quantitative data was gathered regarding the students' level of SA during the simulations, and qualitative data were collected via subsequent semi-structured interviews.

Participants and Procedures

A convenience sample of third-year paramedicine students participated in two simulated emergency scenarios; one in an immersive setting, and one in a non-immersive environment. Students were randomly allocated to one setting, and then subsequently participated in the alternate setting. All scenarios were randomly selected for each student and included simulated injuries such as head trauma or pelvic fracture within environments including a house fire, and motorbike or motorcar accident. The Situation Awareness Global Assessment Technique (SAGAT) was utilised to assess their level of SA at pre-determined points in each scenario.

The immersive simulated scenarios took place in a built-for-purpose interactive simulation centre within the university. The centre uses 360° visual projections of external environments with embedded environmental sound. A variety of environments were utilised (day and night scenes), for example, a busy roadside, sports regatta, and suburban house. All simulated environments provided a high level of sensory stimulation, both visual and auditory, which aimed to increase cognitive load in comparison with the conventional non-projected simulation setting.[32] In addition, a full-size, fully stocked ambulance replica was permanently positioned at one end of the room and added to the realism of the environment.

The subsequent one-to-one semi-structured interviews were conducted in person in a private room to examine student perceptions of their experiences during the simulations as well as their views regarding SA. Interviews were undertaken 1-2 weeks after the simulations, and were audio-recorded and transcribed verbatim.

Instrumentation

The SAGAT was developed to examine situational awareness in combat pilots.[33] Using the SAGAT, a simulation of the system of interest is utilised and the session is stopped at multiple times with participants being questioned regarding their perceptions of various aspects of the situation at that time. The queries should encompass all three components of SA: recognition, interpretation, and prediction of future events.[34] Each answer is scored as correct or incorrect, often within limits as deemed appropriate by content experts,[35] with the final score being the percentage of correct answers provided.

The SAGAT has been used in a wide range of settings, such as aviation,[36] military,[37,38] train traffic

control,[39] medicine,[40] nursing,[41] and even human-robot interaction,[42] to provide an objective appraisal of SA. Previous investigations of SA within paramedicine have also utilised the SAGAT.[43-45]

The queries used in our study were relevant and appropriate to the simulation and every effort was made to ensure they were similar to how an out-of-hospital provider would think and process information in a real emergency. Multiple subject matter experts were consulted to assist with developing the queries and determining acceptable answers for each level of SA. Some answers were discussed to have an acceptable range of answers, such as would be used for vital signs or time. For instance, if a student was asked "How far away are we from the hospital?" – the answer would be acceptable if they responded within 1 mile of the actual answer. Upon completion of the data collection, all responses were reviewed and determined to be correct or incorrect.

Although the SAGAT is widely used, other tools exist for the measurement of SA. A meta-analytical comparison of two commonly used tools to measure SA, the Situation Present Assessment Technique (SPAM)[46] and the SAGAT[35] found the latter to be more sensitive and reliable, as well as valuable in many settings.[47]

Data Analysis

Descriptive quantitative data analysis was completed using IBM SPSS v26 and thematic analysis methodology was utilised to examine the quantitative data.[48]

Ethics

Ethical approval for this study was gained from Monash University Human Ethics Committee (approval number 18125).

Results

SAGAT

Eighteen paramedicine students participated in this pilot study with an equal number of females and males. Overall results indicate that students demonstrated lower SA in immersive simulations compared with non-immersive simulations, scoring 79% and 92% respectively. This was especially apparent for the initial (level 1) Recognition component of SA with a score of 60% during the immersive simulation, compared to 86% demonstrated during the non-immersive setting. Scores achieved for Interpretation (level 2) were 81% and 92% respectively, and the same score (97%) was achieved in both types of simulations for the Prediction (level 3) component.

Interviews

Eight students participated in the interviews, which took 28-45 minutes each. Overall, all interviewees were able to describe at least a basic understanding of SA and perceived it to be important within paramedicine primarily for the safety of the patient and the paramedic. For example, awareness of either a relatively static or changing environment may increase understanding of what has happened to the patient (e.g. an empty medicine container nearby or a changing conscious state), or enable the perception of present or evolving potential dangers in the environment (e.g. aggressive bystander behaviour or a crumbling rock face). All of which are encompassed in practicing a dynamic risk assessment.

Thematic analysis

Three themes were identified during the thematic analysis process – Authenticity, Overwhelm, and Disorganisation.

(i) Authenticity

All but one student considered the immersive simulation to be a realistic setting, although a few mentioned that the fidelity would be enhanced with the additional utilisation of actors as simulated patients within the scenario.

> "…using actors, for example, is probably…another layer that you could have in an ideal world. That would be fantastic." Interviewee #2

Generally, the immersive simulation was perceived to be a useful preparation for real-world clinical practice and many were keen for students to have more practice with immersive simulation settings.

> "I think going to do something like even like half a day of that in like, once or twice a month would be very, very beneficial" Interviewee #1
>
> "…we probably should be making a lot… better use out of [the simulation centre] rather than just doing things in practice classes" Interviewee #4

(ii) Overwhelm

Students reported feeling overwhelmed, especially in the initial stages of the simulation. The overwhelm appeared to be multi-factorial, with the intensity of the sound and lights and the unfamiliar nature of the experience being major influences.

> "And then all of the things that kind of just put you off a little bit, and then like it just felt very loud and overwhelming. And it made me feel quite stressed" Interviewee #1
>
> "…already there's…an overwhelming amount of stimuli happening…you do

notice the little things, but you kind of look at it, and you go, that's unimportant, so you're not going to bother thinking about it…So yeah…you're trying to minimise the amount of things you're thinking through." Interviewee #7

"I guess when you initially walked in hearing all the noises, it was a shock" Interviewee #8

(iii) Disorganisation

None of the students had been exposed to an immersive simulation in our simulation centre previously to this study, and although a few students felt they performed well clinically, many expressed that the situation adversely impacted their scenario management. They reported difficulty in recall of basic knowledge, disorganisation of thoughts as well as their clinical approach, and a feeling of being able to concentrate only on one thing at a time. Typically, they felt much more comfortable managing a simulated emergency scene in the non-immersive scenario room. They had practised in this type of environment in previous scenario training experiences throughout their undergraduate course and felt more able to use an organised clinical approach.

"I was really surprised at how disorganised my thoughts were going into the simulation room…it impacted my performance because I was distracted by so much" Interviewee #3

"…normally I would probably take in the whole monitor at once rather than just look at the one thing and focus on that maybe because there was so much going on" Interviewee #4

Discussion

This study examined the SA of third-year undergraduate paramedicine students during both the immersive simulations and during more conventional non-immersive settings. Subsequent interviews were conducted to examine their knowledge of SA and discuss their experiences of the two different types of simulation in which they had participated.

The SAGAT tool was used to assess their SA at all three levels - recognition, interpretation, and prediction - at various times throughout the simulations. Overall, the paramedicine students demonstrated lower levels of SA in the immersive simulation compared with the non-immersive simulation. Most errors occurred in the initial stages of the scenario, within the 'recognition' component of SA, which is consistent with other studies in paramedicine [44,49] as well as commercial aviation.[50] Interview data suggests that a contributing factor to this finding may include that this study was the first time the students were exposed to immersive simulation within the simulation centre. They did not know what to expect, felt anxious, and became quickly overwhelmed with the high level of sensory stimulation upon entering the room; all responses that have previously been reported during immersive simulation.[51,52]

Follow-up interviews suggested that the immersive nature of the simulation adversely affected their scenario management with difficulty in recall of basic knowledge, disorganisation of thoughts as well as their clinical approach, and being able to concentrate on only one thing at a time. Multiple distractions within a dynamic environment, such as those apparent within the immersive simulation may result in a reduction of working memory, and may adversely affect SA.[6] This memory limitation is likely to be a factor in the student's reported difficulties in patient management. Difficulties with working memory capacity may result in forgetting vital pieces of information or difficulties with its subsequent interpretation. This is especially the case for a novice who, without the development of cognitive schema via experience, must predominantly rely on working memory for information processing.[53] Although expertise in a cognate area can mitigate this effect, the lack of recognition of vital information is a common cause of suboptimal SA and human error. [54] A novice in any high-stress, highly dynamic domain tend to be challenged to perform well in Level 1 SA "recognition'.[55] Previous research in paramedicine has shown that paramedic students may lack SA due to being stressed as well as failing to focus and lacking an overall organized approach.[44] Even after achieving a degree of expertise in an area, performing well at Level 1 SA can be demanding. [55] Error at the Level 1 stage has long been known as the predominant source of error in aviation. [56] Within healthcare this is supported by a study of critical errors in anaesthesia and critical care, where it was reported that errors occurred predominantly (38%) at the SA level of perception.[54] Although SA research within paramedicine is in its early stages, the element of information recognition is thought to be the most important aspect of SA within the discipline.[44] For instance, a paramedic may be able to accurately interpret the meaning of a low blood pressure, and may also be able to accurately predict how a patient with low blood pressure may progress clinically, but if they fail to recognize what the blood pressure is in the first place then it would be impossible for them to correctly interpret and predict.

Paramedicine students generally found the immersive simulations to be quite stressful. However, it has been reported that once a student has learned a clinical skill, the increase in cognitive burden inherent in a simulation may be valuable for skill practice and contextualisation within a pressurised situation, as well as self-reflection.[51] Thus, the students' sense of stress that may be felt in immersive simulations are likely outweighed by the educational value of the method.

Limitations

This study did have several limitations. Although this pilot study has identified important information regarding the effect of immersive simulation on situational awareness in paramedicine students, our results are limited by the number of students participating and therefore we did not have the ability to calculate any statistics that would be statistically significant. The utilisation of larger cohorts would enable the calculation of more meaningful inferential statistics. Also, as we recruited volunteer students, self-selection bias is possible where only students who were confident in their clinical skills and/or scenario performance participated. Gathering data from an entire year-level paramedicine student cohort may mitigate this potential bias. The additional factor of all students originating from one university within one country requires caution to be exercised with the generalisation of results. Furthermore, there was no capacity to control the students' prior experience and exposure to various clinical situations during their clinical placements. For example, a student presented with a simulated emergency that they had previously faced in real life, may respond differently to those with no previous experience. In addition, there was no true washout period between scenarios for the students, which may have resulted in adjustments to their practice in their second scenario of the day.

Future Research

Further research into this issue is warranted using larger, fully randomised cohorts within multi-institutional settings. Longitudinal studies of SA in both students and professional paramedics would afford some understanding of how SA develops or changes throughout the lifecycle of a paramedic. Also, an examination of the effect of SA on clinical performance would be valuable to inform and improve future clinical curricula. In addition, our study methodology could be utilised for the examination of SA within other healthcare professional groups, especially those in cognitively demanding, high-stress professions such as emergency nursing or medical professionals.

Conclusion

Situational awareness is an important component within paramedicine and involves the ability to appropriately recognise information, interpret it correctly, and then make an accurate prediction of how this information may influence future events. Paramedicine students in our study demonstrated lower levels of SA during an immersive simulated scenario compared with a conventional non-immersive setting. These results were particularly evident in the initial 'recognition' stage of SA. Students reported that the immersive environment increased difficulty in basic knowledge recall, organisation of their thoughts and clinical approach, and the ability to concentrate on multiple issues simultaneously. As a lack of SA may contribute to healthcare errors, its assessment and development must be addressed within paramedicine education. The utilisation of immersive simulation in paramedicine curricula may play an important role in this area.

Competing Interests

The authors have no conflicts of interest to declare.

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