The affordances of Immersive Virtual Reality Clinical Simulation within Healthcare Education: A Scoping Review Protocol

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Abstract

Whilst clinical simulation is recognised as an effective educational tool within the healthcare community, the inability to offer authentic simulation learning environments remains problematic. The latest advances in technology such as immersive virtual reality (IVR) now offer opportunities to enhance traditional practice to the extent that may transform learning. Determining potential benefits, drawbacks and affordances of IVR simulation may help provide an understanding of its effectiveness. The aim of this scoping review is to understand the extent of immersive virtual reality technology within clinical simulation education and its relationship to psychometric and physiological measures.

Healthcare workers or those studying toward a clinical qualification and perform clinical simulation within an Immersive virtual reality environment will be included in the review. Those who perform comparative replication of skills within IVR will be excluded as the review requires authenticity and innovation rather than a comparator or replicated real-world skill.

Methods: The databases to be searched include ERIC, AMED, PsychINFO (OVID); CHINAHL, MEDLINE (EBSCO); SCOPUS and Web of Science. Grey literature will be searched in Google Scholar and a review of included source reference lists for similar topics will identify relevant studies. Data will be exported via Endnote™ X9 (Clarivate Analytics, PA, USA) to Covidence™ (Veritas Health Innovation, Melbourne, Australia) for peer review. Final results will be presented in tabular form in addition to a narrative summary of findings.

Introduction

One of the goals for a clinical educator is to prepare the healthcare professional with experiences that help transfer theories and concepts of technical skill and knowledge to real life. The learning experience in turn lends itself to a process of ‘knowing, acting, being and becoming a professional’[1]

and provides a foundation toward knowledge and expertise when managing a patient. This however often requires a variety of experiential learning encounters where specific skills, capabilities and practice is encountered. Within the context of emergency care, these encounters can occur both within the real world and the simulation environment.

Whilst complexity and variety are encountered with a real patient, clinical simulation has several advantages[2]. Clinical simulation is able to replicate symptoms that resemble a particular condition within a safe confide. This then creates a practice environment with no risk to a patient[3] and the ability to develop communication, procedural and problem-solving skills[4] with the support of an expert facilitator[5]. Whilst simulation has value, authenticity when compared to a real patient can often be difficult to achieve[2].

Clinical simulation fidelity has many forms. Simulation can range from low fidelity mannikin based simulation to those that include immersive virtual reality[6]. Whilst each has its own competency, they are often used as an educational scaffold (from low to high) to influence and develop practice. However, the clinical simulation environment is often non-authentic and sterile with minimal real-world environmental distractions or influence. This in itself does not authentically replicate the complexity and chaos of a real-world critical emergency care environment. With this, it is possible to enhance the clinical simulation and its environment to provide a level of authenticity with the use of immersive virtual reality (IVR)[7].

Immersive Virtual Reality (IVR) provides an authentic learner experience that facilitates engagement with simulated high-risk environments within healthcare. This can be in the form of a virtual patient[8] or environment[6]. IVR, therefore, offers a unique opportunity to experience and explore a range of simulated environments, phenomena and objects regardless of physical location[9]. Whilst research has investigated clinical simulation in conjunction with a variety of virtual reality tools[7], reports on the potential stressors and immersion affordances of IVR simulation seem somewhat amiss.

Learning is often aligned with learner emotional stress as they move beyond the bounds of their prior knowledge to new and unknown environments[10]. Physiological stress indicators can be measured via quantitative biometric data such as heart rate, galvanic skin resistance (sweat), and blood pressure[7]. Measuring learner stress indicators can be aligned to significant qualitative learning events or critical learning incidents, and thus biometric data can be used to triangulate subjective learner feedback (psychometric measures) on the impact of a learning intervention or simulation[7].

Authentic IVR learning practices facilitate learning through the development and initiation of student-centred authentic tasks[11]. This involves critical inquiry, problem-solving and meaningful real-world outcomes that lead to the construction of knowledge. Within an authentic context, clinical simulation should offer a similar experience to those undertaken by real-world clinicians with educators able to craft the experience to resonate with the “situated (lived) experience” [12]. However, whilst exposing a student to a clinical environment, there should also be protection from the dangers and nonessential influences of the real-world[6].

While there have been many research studies that focus on the stressors of clinical simulation [7,13,14] none focus on the impact of IVR when used within clinical simulation. With this, it is unknown if research exists that investigates IVR enhanced clinical simulation learning environments that more authentically model the stress and complexity of real-world critical care scenarios.

What is already known about this topic?

• Clinical simulation is an effective and widespread training methodology in health education disciplines[6].

• Immersive Virtual Reality enables the design of authentic learning experiences[6].

• Virtual Reality has predominantly been used for clinical procedure training in health education, with limited evidence of engagement with the development of student experience or stress[6].

The aim of this scoping review is to understand the extent of immersive virtual reality technology within clinical simulation education and its relationship to psychometric and physiological stress measures. To achieve this aim a scoping review will help with the following:

1. Within the PCC (Population, Concept, Context) study criteria a review will investigate both published and grey literature to identify the affordances of Immersive Virtual Reality Clinical Simulation within Healthcare Education;

2. Map key characteristics related to the concepts of inclusion (Emergency care, IVR, Clinical simulation, Stress and Education) to gain insight into the range and extent of research in this area;

3. Provide a narrative of the key characteristic's related to the concept; and

4. Identify questions or knowledge gaps for future research.

A preliminary search of MEDLINE, the Cochrane Database of Systematic Reviews and JBI Evidence Synthesis was conducted and no current or underway systematic reviews or scoping reviews on the topic were identified.

Review question

The following research questions were formulated within a 'Population, Concept, Context (PCC)' framework.

• Question: In what ways can immersive virtual reality (Concept) enhance the authenticity of traditional clinical simulation (Context) healthcare training (Population)?

• Sub-Question 1: What is the correlation between immersive virtual reality enhanced clinical simulation healthcare training and participant stress response?

• Sub-Question 2: In what ways does increasing clinical simulation training authenticity impact healthcare learning?

Keywords

Healthcare; Immersive Reality; Clinical simulation; Stress; Education design.

Inclusion criteria

Participants

Participants include qualified clinical personnel or students studying toward a healthcare/clinical qualification. Those whose roles do not include clinical simulation or assessment will be excluded.

Concept

In line with the broad inclusion criteria for a scoping review, alternate technology-based simulation-based training concepts illustrating a realistic clinical environment will be investigated. Those who perform comparative replication of skills within IVR will be excluded as the review requires authenticity and innovation of environment rather than a comparator or replicated real-world skill.

Context

Finally, those with educational assessment or exposure to clinical simulation and/or Immersive Virtual Reality contexts are included. This further includes psychometric and physiological measures. There are no cultural, geographical or gender-based exclusion interests in this setting.

Types of sources

This scoping review will consider both experimental and quasi-experimental study designs including randomized controlled trials, non-randomized controlled trials, before and after studies and interrupted time-series studies. In addition, analytical observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies will be considered for inclusion. This review will also consider descriptive observational study designs including case series, individual case reports and descriptive cross-sectional studies for inclusion.

Qualitative studies will also be considered that focus on qualitative data including, but not limited to, designs such as phenomenology, grounded theory, ethnography, qualitative description, action research and feminist research.

In addition, systematic reviews that meet the inclusion criteria will also be considered, depending on the research question. Text and opinion papers will not be considered for inclusion in this scoping review.

Methods

The proposed scoping review will be conducted in accordance with the JBI methodology for scoping reviews[15]. The review title has been registered with Open Science Framework (OSF)[16].

Search strategy

The search strategy will aim to locate both published and unpublished studies. A three-step search strategy will be utilized in this review. First, an initial limited search of AMED (OVID) and Web of Science will be undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms will be used to describe the articles. This will then be used to develop a full search strategy for AMED (OVID) and Web of Science (see Appendix 1). The search strategy, including all identified keywords and index terms, will be adapted for each included database and/or information source. The reference list of all included sources of evidence will be screened for additional studies.

For pragmatic reasons studies published in full text English language, with human participants from the earliest available date will be included. The databases to be searched include ERIC, AMED, PsychINFO (OVID); CHINAHL, MEDLINE (EBSCO); SCOPUS and Web of Science. Sources such as books, thesis, conference and symposium proceedings, unpublished studies will be searched in addition to grey literature including Google Scholar and a review of reference lists within the included articles.

Study/Source of evidence selection

Following the search, all identified citations will be collated and uploaded into Endnote™ X9 (Clarivate Analytics, PA, USA) with duplicates removed. Following a pilot test, titles and abstracts will then be screened by two or more independent reviewers for assessment against the inclusion criteria for the review. Potentially relevant sources will be retrieved in full and their citation details imported into the Covidence™ (Veritas Health Innovation, Melbourne, Australia). The full text of selected citations will be assessed in detail against the inclusion criteria by two or more independent reviewers (SA and TC). Reasons for exclusion of sources of evidence at full text that do not meet the inclusion criteria will be recorded and reported in the scoping review. Any disagreements that arise between the reviewers at each stage of the selection process will be resolved through discussion, or with an additional reviewer (CS). The results of the search and the study inclusion process will be reported in full in the final scoping review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping review (PRISMA-ScR) flow diagram[17].

Data extraction

Data will be extracted from papers included in the scoping review by two or more independent reviewers using a data extraction tool developed by the reviewers (SA and TC). The data extraction instrument was adapted from the JBI SUMARI tool to answers the review questions. The data extracted will include specific details about the participants, concept, context, study methods and key findings relevant to the review questions.

A standardised data extraction form will be developed in line with the JBI data extraction tool (see Appendix 2). This form will be published as an appendix in the final review output. The data extraction tool will be modified and revised as necessary during the process of extracting data from each included evidence source. Modifications will be detailed in the scoping review. Any disagreements that arise between the reviewers will be resolved through discussion, or with an additional reviewer. If appropriate, authors of papers will be contacted to request missing or additional data, where required.

Data analysis and presentation

The assessment findings of the final review will be presented in a tabular form with a narrative summary. The mapping of the results will be reported by providing a visual representation of the data to support breadth, extent and range of activity related to the research questions. All research methods findings will be reported in narrative synthesis that align with the review objective and questions.

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Declarations

Nil

Author contributions

SA established the need for a scoping review and drafted the initial protocol. TC and CS reviewed, revised and helped produce the final protocol manuscript.

Conflicts of interest

Nil

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Appendices

Appendix I: Search strategy

AMED (via OVID)

1. 1 *AND* 2
2. 3 *AND* 4
3. 1 *AND* 5
4. 3 *AND* 5
5. 1 *AND* 2 *AND* 3 *AND* 4
6. 1 *AND* 2 *AND* 3 *AND* 4 *AND* 5
7. 1 *AND* 2 *AND* 3 *AND* 4 *AND* 5 AND English AND Human

Search terms

Search #	Query
1 Healthcare	paramedic OR Emergency paramedic OR Paramedic person OR Emergency medical technician OR EMT OR Ambulance person OR paramedic student OR Medical student OR medical OR clinical OR paramedic OR ambulance OR EMS OR Emergency medical service OR emergency medical OR first responder
2 Virtual Reality	virtual reality exposure therapy OR exposure therapy OR virtual reality education OR Augmented reality OR VR OR AR OR Virtual world OR Virtual environment OR Mixed reality OR Immersive environment OR Virtual space OR virtual reality OR MMR OR XR OR immersive cave OR virtual OR immersive learning OR cave OR immersive
3 Clinical Simulation	Simulation OR Patient Simulation OR Simulation training OR High fidelity simulation training OR High fidelity simulation OR clinical simulation OR high fidelity clinical simulation OR high fidelity OR high-fidelity OR manikin OR Laerdal OR mannequin
4 Stress	Stress OR Anxiety OR biological stress OR Cognitive reserve OR Mental process OR brain reserve OR Cognitive Behavioral Therapy OR Cognitive Behavioural Therapy OR Performance Anxiety OR Test Anxiety Scale OR Manifest Anxiety Scale OR Test Anxiety OR cognitive OR emotion OR biometric
5 Education	DBR OR EDR OR design based research OR design-based-research OR educational design research OR educational-design-research OR pedagogy OR andragogy OR heutagogy OR self-determined learning OR self-regulated learning OR self determined learning OR self regulated learning OR clinical education OR medical education

Web of Science

1. 1 *AND* 2
2. 3 *AND* 4
3. 1 *AND* 5
4. 3 *AND* 5
5. 1 *AND* 2 *AND* 3 *AND* 4
6. 1 *AND* 2 *AND* 3 *AND* 4 *AND* 5
7. 1 *AND* 2 *AND* 3 *AND* 4 *AND* 5 AND English AND Human

Search #	Query
1 Healthcare	paramedic OR Emergency paramedic OR Paramedic person OR Emergency medical technician OR EMT OR Ambulance person OR paramedic student OR Medical student OR medical OR clinical OR paramedic OR ambulance OR EMS OR Emergency medical service OR emergency medical OR first responder
2 Virtual Reality	virtual reality exposure therapy OR exposure therapy OR virtual reality education OR Augmented reality OR VR OR AR OR Virtual world OR Virtual environment OR Mixed reality OR Immersive environment OR Virtual space OR virtual reality OR MMR OR XR OR immersive cave OR virtual OR immersive learning OR cave OR immersive
3 Clinical Simulation	Simulation OR Patient Simulation OR Simulation training OR High fidelity simulation training OR High fidelity simulation OR clinical simulation OR high fidelity clinical simulation OR high fidelity OR high-fidelity OR manikin OR Laerdal OR mannequin
4 Stress	Stress OR Anxiety OR biological stress OR Cognitive reserve OR Mental process OR brain reserve OR Cognitive Behavioral Therapy OR Cognitive Behavioural Therapy OR Performance Anxiety OR Test Anxiety Scale OR Manifest Anxiety Scale OR Test Anxiety OR cognitive OR emotion OR biometric
5 Education	DBR OR EDR OR design based research OR design-based-research OR educational design research OR educational-design-research OR pedagogy OR andragogy OR heutagogy OR self-determined learning OR self-regulated learning OR self determined learning OR self regulated learning OR clinical education OR medical education

Appendix II: Data extraction form

Study year/author(s)/ country of origin/numbers	Stress characteristics	health discipline	VR technology	Education design	Clinical simulation type	Outcome	Key findings	Notes