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EDUCATION AND TRAINING

Realism in paediatric emergency simulations: A prospective comparison of *in situ*, low fidelity and centre-based, high fidelity scenarios

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Abstract

Objective: To measure scenario participant and faculty self-reported realism, engagement and learning for the low fidelity, *in situ* simulations and compare this to high fidelity, centre-based simulations.

Methods: A prospective survey of scenario participants and faculty completing *in situ* and centre-based paediatric simulations.

Results: There were 382 responses, 276 from scenario participants and 106 from faculty with 241 responses from *in situ* and 141 from centre-based simulations. Scenario participant responses showed significantly higher ratings for the centre-based simulations for respiratory rate ($P = 0.007$), pulse ($P = 0.036$), breath sounds ($P = 0.002$), heart sounds ($P < 0.001$) and patient noises ($P < 0.001$). There was a significant difference in overall rating of the scenario reality by scenario participants in favour of the centre-based simulations ($P = 0.005$); however, there was no significant difference when rating participant engagement ($P = 0.11$) and participant learning ($P = 0.77$). With the centre-based scenarios, nurses rated the reality of the respiratory rate ($P < 0.001$), blood pressure ($P = 0.016$) and abdominal signs ($P = 0.003$) significantly higher than doctors. Nurses rated the overall reality higher than doctors for the centre simulations (96.8% *vs* 84.2% rated as realistic, $P = 0.041$), which was not demonstrated in the *in situ* scenarios (76.2% *vs* 73.5%, $P = 0.65$).

Conclusion: Some aspects of *in situ* simulations may be less 'real' than centre-based simulations, but there was no significant difference in self-reported engagement or learning by scenario participants. Low fidelity, *in situ* simulation provides adequate realism for engagement and learning.

Key words: *high fidelity simulation training, paediatric emergency medicine, patient simulation, resuscitation, simulation training.*

Key findings

- Some aspects of *in situ* simulations may be perceived as less 'real' than centre-based simulations
- There was no difference in engagement or learning between the modalities.
- *In situ* simulations utilising the ALSi, combined with a low fidelity manikin, provide effective educational realism.

Introduction

An exciting simulation that captures the imagination, triggering physiological responses and the execution of ingrained clinical algorithms, is a social and psychologic endeavour.[1] Reality can be defined in three domains: physical, conceptual and emotional/experiential. Physical realism is what we can see and touch for example the manikins. The conceptual domain involves 'if – then' algorithms concerned with problem solving, decision making and prediction for example if the patient stops breathing the oxygen saturations will fall. The emotional and experiential domain relates to the holistic experience of the simulation and can influence the participants' positive or negative feelings.[1] As educators we strive to create reality as we assume that the more 'real' a scenario is the better the learning outcomes for the participants and ultimately our patients.

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TABLE 1. *Centre-based and* in situ *simulated learning environments*

	Advantages	Disadvantages
Simulation centre	• Participants are removed from clinical duties • Scenarios and debriefing sessions can be longer • Interference with patient care is minimised	• Expensive outlay • Expensive to attend • Unfamiliar environment • Dissimilar equipment • Missing team member roles due to rostering constraints

In situ	• Relatively inexpensive to set up
	• Cheap to attend
	• Team to train in their typical roles
	• Familiar setting
	• Use actual department equipment and resources
	• Use local system processes
	• Minimise the space requirements
	• Minimise travel time incurred
		• Difficulty rostering sessions
		  ○ room availability
		  ○ participant and faculty availability
		• Potential to interrupt patient care
		• Frequent interruptions
		• Higher cancellation rates
		  ○ empty patient areas might not be available when desired
		  ○ simulations may need to be aborted to make site available for patient care
		• The cost of real supplies used during simulation
		• Relative difficulty of organising audio visual recording or no recording
		• Less time for didactic teaching and debriefing
		• Difficulty of reaching providers on all shifts
		• Amplify safety hazards of simulation itself, including:
		  ○ maintaining control of simulated medications and equipment
		  ○ requiring mitigation efforts such as labelling and securement of simulation supplies
		  ○ development of consistent policies and procedures for *in situ* training

The current evidence base for effective training supports local, unit-based and multi-professional training, with appropriate manikins, and practice-based tools to support the best care.[2] Programmes using these principles have shown not only improved learning outcomes for participants, but also improved patient outcomes.[3–8] Simulation training can also be used as a tool to identify latent errors within hospital systems and as part of a participant or team assessment process.[9–15]

The majority of simulations occur either in a purpose built centre or in the real clinical environment (*in situ*). A recent paper by Couto *et al.*[16] summarises the differences between the two environments and these are described in Table 1. Petrosoniak *et al.*[17] have described the key benefits of *in situ* simulation, which include improvements in provider performance and teamwork, patient safety and hospital systems.

In our facility, we run both *in situ* and centre-based simulation programmes. Although there may be no difference in knowledge acquisition between locations,[4] teamwork training may be more effective *in situ*.[16] In the ED, we have recently changed our simulation set up to use the ALSi monitor simulator (iSimulate, Fyshwick, ACT, Australia) with low fidelity manikins (Laerdal ALS Baby or MegaCode Kid, Stavanger, Norway). For simplicity of facilitating the simulations we stopped using the SimPad functions that simulated the respiratory and heart sounds on

TABLE 2. *Degree of fidelity provided by different manikin/monitoring set ups*

	ALS Baby/Nursing kid/MegaCode Kid	SimJunior/SimBaby
Heart rate	iSimulate	Laerdal monitor simulator/palpable pulse
Cardiac rhythm	iSimulate	Laerdal monitor simulator
Respiratory rate	iSimulate/Faculty	Laerdal monitor simulator/chest wall movement
Blood pressure	iSimulate	Laerdal monitor simulator
Oxygen saturation	iSimulate	Laerdal monitor simulator
Pulse	Faculty	Palpable manikin pulse
Breath sounds	Faculty	Audible manikin sounds
Heart sounds	Faculty	Audible manikin sounds
Pupils	Faculty	Faculty
Patient noises	Faculty. Baby noises added to iSimulate for ALS Baby scenarios	SimJunior: Faculty via hidden speaker in manikin. SimBaby has realistic crying noises
Abdominal signs	Faculty/Moulage	Faculty/Moulage. SimJunior has abdominal distension
External signs	Faculty/Moulage	Moulage

the manikins. We were concerned that using such a low fidelity set up, participants may not appreciate enough realism and this may impact on their overall engagement and learning. Studies have emphasised the importance of physical signs in the conveyance of realism, with higher ratings of realism for high fidelity manikins, especially rating chest wall movement and palpable pulses as important,[18] the 'lack of fidelity of the neonatal manikin to a human neonate' being a major limitation of one programme[19] and a general consensus of a direct correlation between simulation validity and effective learning.[20] There is even increasing use of equipment such as Simulation Stethoscopes[21,22] in simulated learning environments to increase specific areas of realism. In contrast, our 1 day centre-based programme uses standard high fidelity manikins (Laerdal SimJunior and SimBaby, Stavanger, Norway). Table 2 illustrates the differences between the *in situ* and centre-based equipment.

The aim of this study was to measure participant and faculty self-reported realism, engagement and learning for the low fidelity, *in situ* simulations and compare these responses to those from the high fidelity, centre-based simulations.

Method

Study design

A prospective survey of scenario participants and faculty distributed at the end of each *in situ* or centre-based scenario and collected anonymously before respondents either left the *in situ* simulation or continued with the centre-based programme. This method was intended to achieve a 100% response rate.

Setting

The study scenarios occurred either in the ED of The Children's Hospital at Westmead, Australia (a large tertiary referral centre with >55 000 attendances each year) or in The Kim Oates Australian Paediatric Simulation Centre (KOAPSC), which is a purpose built simulation centre attached to The Children's Hospital at Westmead. The equipment used and the relative fidelity of manikins is described in Table 2. Recruitment occurred for 6 months, over two junior medical officer terms, from August 2015 to January 2016 inclusive. Scenarios from two, 1 day Paediatric Emergency Crisis Training (PECT) courses were included and all *in situ* simulations in the ED during the 6 month timeframe. The ED runs an interdisciplinary, *in situ*, paediatric emergency simulation programme with scenarios that are timetabled weekly. Table 3 describes the scenarios and their locations.

Participants

Medical and nursing staff working in the ED at the time of the *in situ* scenario would participate in the simulation. The centre-based scenarios were interdepartmental and included doctors and nurses from the general medical ward as well as ED staff. Some participants would have participated in both types of scenarios. Faculty were all trained and already working as faculty in the simulation programme prior to the start of the study. All scenario participants and faculty who were involved in the simulations answered the survey after the simulation debrief. Participants were informed at the start of the simulation, as part of the simulation briefing, that they would be asked to fill in the survey, but there was no obligation to do so. As simulations are a standard part of education and training in our organisation participants will have had previous exposure to simulations to varying degrees depending on length of employment.

Survey

A self-completed, 9 point Likert scale, anonymous survey was developed to measure participant perception of 12 individual simulation signs, as well as overall perception of how well the scenario simulated a real patient, overall engagement and an estimate of whether the realism was sufficient

TABLE 3. *Summary data of scenarios and participants*

Scenario	*In situ*/ centre	Manikin	Monitoring	Participant responders, *n*	Faculty responders, *n*	Total, *n*
Asystole	*In situ*	ALS Baby	iSimulate	11	2	13
Tracheostomy emergency	*In situ*	Nursing kid	iSimulate	13	8	21
Anaphylaxis	*In situ*	MegaCode Kid	iSimulate	15	6	21
Deteriorating asthma	*In situ*	MegaCode Kid	iSimulate	7	2	9
Code crimson	*In situ*	MegaCode Kid	iSimulate	16	4	20
SVT	*In situ*	ALS Baby	iSimulate	16	4	20
Head injury	*In situ*	MegaCode Kid	iSimulate	14	5	19
Septic infant	*In situ*	ALS Baby	iSimulate	9	3	12
Unwell neonate	*In situ*	ALS Baby	iSimulate	10	2	12
VT/VF	*In situ*	MegaCode Kid	iSimulate	19	5	24
Penetrating trauma	*In situ*	MegaCode Kid	iSimulate	20	5	25
Status epilepticus	*In situ*	ALS Baby	iSimulate	19	4	23
Obstructed airway	*In situ*	MegaCode Kid with neck modification	iSimulate	18	4	22
Airway burn	Centre	SimJunior	Laerdal monitor simulator	17	9	26
Deteriorating bronchiolitis	Centre	SimBaby	Laerdal monitor simulator	18	13	31
Multiple medical problems	Centre	SimBaby	Laerdal monitor simulator	18	10	28
Hypovolaemic shock	Centre	SimJunior	Laerdal monitor simulator	18	9	27
Severe trauma	Centre	SimJunior	Laerdal monitor simulator	18	11	29
Total				276	106	382

for them to learn from the scenario. A similar survey was completed by the faculty; however, they rated participant engagement and learning. The surveys were adapted, by an expert panel, from a previously published instrument validated for medical student self-assessment and adapted to measure simulation tools[22,23] and pretested on a small sample prior to commencing the trial. The surveys are available in Appendix S1.

Statistical methods and sample size estimation

Data were analysed using SPSS version 22.0 (IBM, Armonk, NY, USA). We estimated that we would need 90 participants per group to provide the power to show that differences of above 20% between groups would be statistically significant (power = 80%, $P < 0.05$). Categorical data were summarised using percentages. Individual responses to each data item were coded on a continuous scale from not at all realistic[1] to realistic[9] and were recoded to categories of not realistic (score 1–3), intermediate (score 4–6) or realistic (score 7–8). Responses of 'not applicable' were omitted from the analyses. Categories were compared between locations and participants using cross-tabulations and exact χ^2 test. *P*-values less than 0.05 were considered statistically significant. Cronbach's alpha was used to report scale reliability for the *in situ* and centre-based simulation responses.

Results

Of the 276 scenario participant responses, where the data was recorded, 135 (53.4%) were from doctors and 118 (46.6%) were from nurses. Of the 106 faculty responses, 35 (43.8%) were from doctors and 45 (56.2%) from nurses. In total there were 241 responses for the *in situ* simulations (187 scenario participants and 54 faculty) and 141 for the centre-based simulations (89 scenario participants and 52 faculty). Table 3 provides more information based on each scenario.

When comparing scenario participant responses for the *in situ* simulations, there were no significant differences in either the reality or educational responses between doctors and nurses. With the centre-based scenarios, nurses rated the reality of respiratory rate ($P < 0.001$), blood pressure ($P = 0.016$) and abdominal signs ($P = 0.003$) significantly higher than doctors. Nurses rated the overall reality higher than doctors for the centre simulations (96.8% *vs* 84.2% rated as realistic, $P = 0.04$), which was not demonstrated in the *in situ* scenarios (76.2% *vs* 73.5%, $P = 0.65$).

Table 4 describes the responses for each of the 15 outcomes, with

TABLE 4. *Summary data of reality ratings and educational benefit from participants and faculty*

Item		Not realistic (score 1–3) *n* (%)		Intermediate (score 4–6) *n* (%)		Realistic (score 7–9) *n* (%)		*P*-value *In situ vs* centre for participants	*P*-value *In situ vs* centre for faculty
		In situ	Centre	*In situ*	Centre	*In situ*	Centre		
Heart rate	Participant	5 (2.8)	0	26 (14.4)	6 (7.1)	149 (82.8)	79 (92.9)	0.06	—
	Faculty	0	—	1 (1.9)	0	53 (98.1)	50 (100)	—	1.00
Cardiac rhythm	Participant	4 (2.5)	0	16 (9.8)	6 (7.6)	143 (87.7)	73 (92.4)	0.37	—
	Faculty	0	0	1 (1.9)	1 (2.3)	51 (98.1)	42 (97.7)	—	1.00
Respiratory rate	Participant	19 (11.5)	2 (2.4)	50 (30.3)	17 (20.7)	96 (58.2)	63 (76.8)	0.007	—
	Faculty	1 (1.9)	0	9 (17.0)	4 (8.0)	43 (81.1)	46 (92.0)	—	0.19
Blood pressure	Participant	4 (2.3)	1 (1.1)	27 (15.5)	8 (9.1)	143 (82.2)	79 (89.8)	0.30	—
	Faculty	1 (1.9)	0	6 (11.3)	1 (2.0)	46 (86.8)	48 (98.0)	—	0.08
Oxygen saturation	Participant	3 (1.7)	1 (1.1)	13 (7.3)	4 (4.5)	161 (91.0)	83 (94.3)	0.65	—
	Faculty	0	1 (2.0)	1 (1.9)	1 (2.0)	53 (98.1)	49 (96.1)	—	0.73
Pulse	Participant	16 (10.4)	1 (1.5)	30 (19.5)	9 (13.8)	108 (70.1)	55 (84.6)	0.036	—
	Faculty	3 (10.7)	0	8 (28.6)	2 (6.3)	17 (60.7)	30 (93.6)	—	0.005
Breath sounds	Participant	32 (23.5)	1 (2.2)	40 (29.4)	10 (22.2)	64 (47.1)	34 (75.6)	0.002	—
	Faculty	5 (13.5)	0	6 (16.2)	5 (19.2)	26 (70.3)	21 (80.8)	—	0.17
Heart sounds	Participant	24 (25.3)	0	31 (32.6)	2 (10.0)	40 (42.1)	18 (90.0)	0.001	—
	Faculty	6 (33.3)	2 (11.8)	5 (27.8)	2 (11.8)	7 (38.9)	13 (76.5)	—	0.10
Pupils	Participant	27 (32.1)	2 (18.2)	19 (22.6)	3 (27.3)	38 (45.2)	6 (54.5)	0.71	—
	Faculty	4 (22.2)	1 (8.3)	2 (11.1)	3 (25.0)	12 (66.7)	8 (66.7)	—	0.49
Patient noises	Participant	28 (18.1)	1 (1.3)	40 (25.8)	14 (18.2)	87 (56.1)	62 (80.5)	<0.001	—
	Faculty	2 (4.9)	0	10 (24.4)	1 (2.2)	29 (70.7)	45 (97.8)	—	<0.001
Abdominal signs	Participant	10 (13.2)	5 (13.2)	24 (31.6)	9 (23.7)	42 (55.3)	24 (63.2)	0.69	—
	Faculty	3 (15.0)	0	7 (35.0)	5 (26.3)	10 (50.0)	14 (73.7)	—	0.18
External signs	Participant	11 (10.7)	1 (3.8)	33 (32.0)	10 (38.5)	59 (57.3)	15 (57.7)	0.58	—
	Faculty	1 (2.4)	0	5 (12.2)	4 (15.4)	35 (85.4)	22 (84.6)	—	1.00

TABLE 4. *Continued*

Item		Not realistic (score 1–3) *n* (%)		Intermediate (score 4–6) *n* (%)		Realistic (score 7–9) *n* (%)		*P*-value *In situ vs* centre for participants	*P*-value *In situ vs* centre for faculty
		In situ	Centre	*In situ*	Centre	*In situ*	Centre		
Overall impression	Participant	7 (3.7)	2 (2.2)	48 (25.7)	8 (9.0)	132 (70.6)	79 (88.8)	0.005	—
	Faculty	0	0	5 (9.3)	1 (2.0)	49 (90.7)	49 (98.0)	—	0.21
		Not engaged (score 1–3) *n* (%)		Intermediate (score 4–6) *n* (%)		Engaged (score 7–9) *n* (%)			
Participant engagement	Participant	4 (2.1)	2 (2.2)	35 (18.7)	8 (9.0)	148 (79.1)	79 (88.8)	0.11	—
	Faculty	0	0	2 (3.7)	0	52 (96.3)	51 (100)	—	0.50
		Disagree (score 1–3) *n* (%)		Intermediate (score 4–6) *n* (%)		Agree (score 7–9) *n* (%)			
Participant learning	Participant	2 (1.1)	0	15 (8.1)	7 (7.9)	168 (90.8)	82 (92.1)	0.77	—
	Faculty	0	0	2 (3.7)	1 (2.0)	52 (96.3)	50 (98.0)	—	1.00

comparisons for *in situ* and centre-based scenarios for scenario participants and faculty responses. Scenario participant responses showed significantly higher rating for the centre-based simulations for respiratory rate ($P = 0.007$), pulse ($P = 0.036$), breath sounds ($P = 0.002$), heart sounds ($P < 0.001$) and patient noises ($P < 0.001$). There was a significant difference in overall rating of the scenario reality by scenario participants in favour of the centre-based simulations ($P = 0.005$), with 132 (70.6%) responses rating the *in situ* simulation as realistic compared with 79 (88.8%) for the centre-based scenarios. However, there was no significant difference when rating participant engagement ($P = 0.11$) and participant learning ($P = 0.77$) by scenario participants.

Faculty responses only showed significantly higher rating for centre-based simulations for pulse ($P = 0.005$) and patient noises ($P = 0.001$). Overall impression by the faculty was not significantly different with 49 responses in each group rating the overall *in situ* (90.7%) and centre-based (98.0%) reality 'realistic' ($P = 0.21$). The rating of scenario participant engagement and learning by faculty was not significantly different between the locations either. Cronbach's alpha was 0.93 for the *in situ* responses and 0.94 for the centre-based responses, indicating excellent internal consistency.

Discussion

We have demonstrated that scenario participants rate simulation centre scenarios, with high fidelity manikins, as providing an overall more realistic simulation of a real patient than low fidelity *in situ* scenarios. In particular respiratory rate, pulse, breath sounds, heart sounds and patient noises seem to be important. Simulation faculty echoed pulse and patient noises as significantly more realistic in the high fidelity, centre-based, scenarios. However, the difference in individual signs or overall realism did not influence self-reported scenario participant engagement with the scenario or the ability

to learn from the scenario. Although centre-based, high fidelity simulation may be more realistic, the *in situ*, low fidelity scenarios provide enough realism to engage and learn.

Finding no difference in engagement and learning is consistent with previous research. Sorensen *et al*. held focus groups after simulations and found that physical context and fidelity were not the most important aspects for learning, highlighting the importance of healthcare professionals participating in authentic teams in their own roles.[24] In neonatal simulation, although only 50% of participants agreed that the manikin provided a real life experience, 97% agreed that the scenarios recreated real life situations and 100% agreed that the debriefings enhanced knowledge.[19] In obstetric emergencies the use of high fidelity manikins in a simulation centre compared to *in situ* training made no significant difference to the acquisition of knowledge.[4] Rudolph *et al*. also emphasise that while physical fidelity is important it is secondary when learning objectives focus on teamwork and crisis resource management. Weak physical fidelity becomes a problem if it reduces a participant's ability to process conceptual reality or causes them to disengage from the emotional or experiential mode, which are essential for cognitive processing and longer-term learning. In contrast, for procedural or task simulations, high physical fidelity is required to develop kinesthetic awareness and muscle memory.[1]

The identification of specific signs as more realistic is variable in the literature and may be context dependent for example a palpable pulse may be rated important in a resuscitation scenario, and less important in a scenario with a talking patient and a heart rate on a simulated monitor. In mock paediatric resuscitations, physical signs depending on auscultation, such as breath sounds and heart sounds, were ranked as less contributory to the realism of scenarios compared to chest wall movement and pulses, which were highly rated.[18] When specifically assessing realism of auscultation the use of a simulation stethoscope has been rated as more realistic; however, the use of the stethoscope made no difference to participants confidence in diagnosis or treatment skills.[22]

As a result of this study we are encouraged that our *in situ* simulation programme, with low fidelity manikins and ALSi, is providing adequate realism for participants to engage and learn.

Limitations

One of the limitations of this study is that we have linked high fidelity manikins with centre-based scenarios and low fidelity manikins with *in situ* scenarios. Caution is required if the results are extrapolated to just high *vs* low fidelity manikins, as the location may have an unconscious effect on perceived sign reality. Zimmermann *et al*.[25] used high fidelity manikins for *in situ* resuscitation simulations and demonstrated improvements in self-perceived teamwork, technical skills, knowledge and anxiety. They invested in a high fidelity manikin 'to improve context and environment'. This additional expense and technical requirement may not be required.

Another limitation of the study is that the participants were different for the comparison groups. The participants were a convenience sample based on whoever attended the scenarios and different individuals' perceptions of the reality of the signs might have influenced the comparative results. Ideally we would have conducted a crossover trial with the same participants, performing the same scenarios in both environments but this was not possible for this study. There may also have been some crossover of participants, with the same respondents taking part in both *in situ* and centre-based simulations, which may have also influenced the results.

Additional information may have been obtained from qualitative, focus group style feedback on the simulations and this would be an area for future research, as participant comments can add valuable insight into the analysis.

Conclusion

Some aspects of *in situ* simulations, using low fidelity manikins and ALSi software, may be less 'real' than centre-based simulations with high fidelity manikins, but there was no significant difference in self reported engagement or learning by participants. Low fidelity, *in situ* simulation provides adequate realism for engagement and learning.

Author contributions

FO, KM, RN, IP and IW conceived the study, designed the trial, and obtained ethics approval. FO, KM, RN, IP undertook recruitment of participants. KM and FO managed the data, including quality control. JP and FO provided statistical advice on study design and analysed the data. KM and FO drafted the manuscript, and all authors contributed substantially to its revision. FO takes responsibility for the paper as a whole.

Competing interests

None declared.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. Participant feedback and faculty feedback.