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The use of human patient simulators for teaching UK pharmacy students about critical care.

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Abstract

Background

The use of human patient simulators (HPSs) has not been studied extensively in UK pharmacy undergraduate curriculums.

Aims

To research the validity of incorporating simulation into the UK MPharm and to appraise its ability to enhance the learning process in critical care teaching.

Method

A controlled, small-group, pilot study of critical care teaching of drug overdose situations was carried out using a HPS, with UK undergraduate pharmacy students at Stage 3 of their 4-year undergraduate course.

Results

HPS sessions involving digoxin and morphine improved both immediate and medium-term knowledge in most cases; improvements were not appreciably different from a conventional tutorial method. Students appeared to derive greater benefit from more than one session, probably due to increasing familiarity with the HPS and associated environment. Feedback was markedly enthusiastic for this new way of teaching.

Conclusion

HPS teaching to pharmacy undergraduates is worth investigating further.

Keywords: *Human patient simulator, critical care, undergraduate*

Introduction

Clinical simulation is a popular approach to teaching in a range of allied health professions (Bradley, 2006). High fidelity mannequins or human patient simulators (HPSs), capable of replicating many physiological functions and disease states at different levels of complexity, are now available. Examples of disciplines where there is evidence of the beneficial impact of HPS teaching include cardiology (Cooper & Taqueti, 2004), surgery (Hariri *et al*, 2004), anaesthesia - both in teaching (Good, 2003) and formal assessment (Morgan *et al* , 2002; Savoldelli *et al* , 2006), nursing (Hoffman *et al*, 2007; Nehring, 2008) and emergency medicine (McFetrich, 2006; Lamb, 2007; Wallin *et al*, 2007). Published reports of the use of HPS in pharmacy education are increasing (Seybert *et al*, 2006; Seybert &Barton, 2007; Fernandez *et al*, 2007; Seybert *et al*, 2008) but there is nothing in a UK context.

Potential advantages are clear. Pharmacy undergraduate education is becoming more markedly clinical in its direction but opportunities to practice near-patient teaching, particularly in a critical care environment, are limited due to large student numbers. We believe there is an opportunity to introduce HPS into the UK undergraduate curriculum to provide an environment where students can learn and develop critical care skills, practicing how to work under pressure.

The University of Portsmouth ExPERT Centre houses a state of the art simulation facility, offering several simulation zones including a critical care unit and several advanced HPSs which can be programmed to respond physiologically, in real time, to intravenous dosing and overdosing of a wide range of drugs and selected antidotes; responses include changes in reflexes and respiratory and cardiac function,

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blood and lung gases. The HPSs can also react realistically to various procedures, including CPR, intubation, ventilation and catheterisation.

The aim of the project was, through a pilot study, to research the validity of incorporating simulation into the MPharm and to appraise its ability to enhance the learning process in critical care teaching.

Methods

The adult METI Human Patient Simulator (Medical Education Technologies Inc., Sarasota, FA) was used in this study.

Subjects

Students were randomly selected from a group of volunteers from the Stage 3 student cohort of the four-Stage undergraduate Master of Pharmacy Course (MPharm) at the University of Portsmouth. Subjects were approximately half-way through the academic year and were deemed to have covered sufficient pharmacology and therapeutics to master the concepts, terminology and intellectual challenges of critical care. Eighteen students were randomised anonymously to one of three groups, using individual case numbers. Each group underwent a programme of teaching and assessment exercises as described in Figure 1.

Scenarios

Scenarios were devised to allow small group teaching using three different methods. The first, control, method (S1) was a conventional didactic, lecturer-led tutorial without the HPS, using only the voice of the lecturer, and an accompanying Powerpoint presentation. Students were allowed to confer at key points in the tutorial to discuss recommendations for patient management, consult information sources where

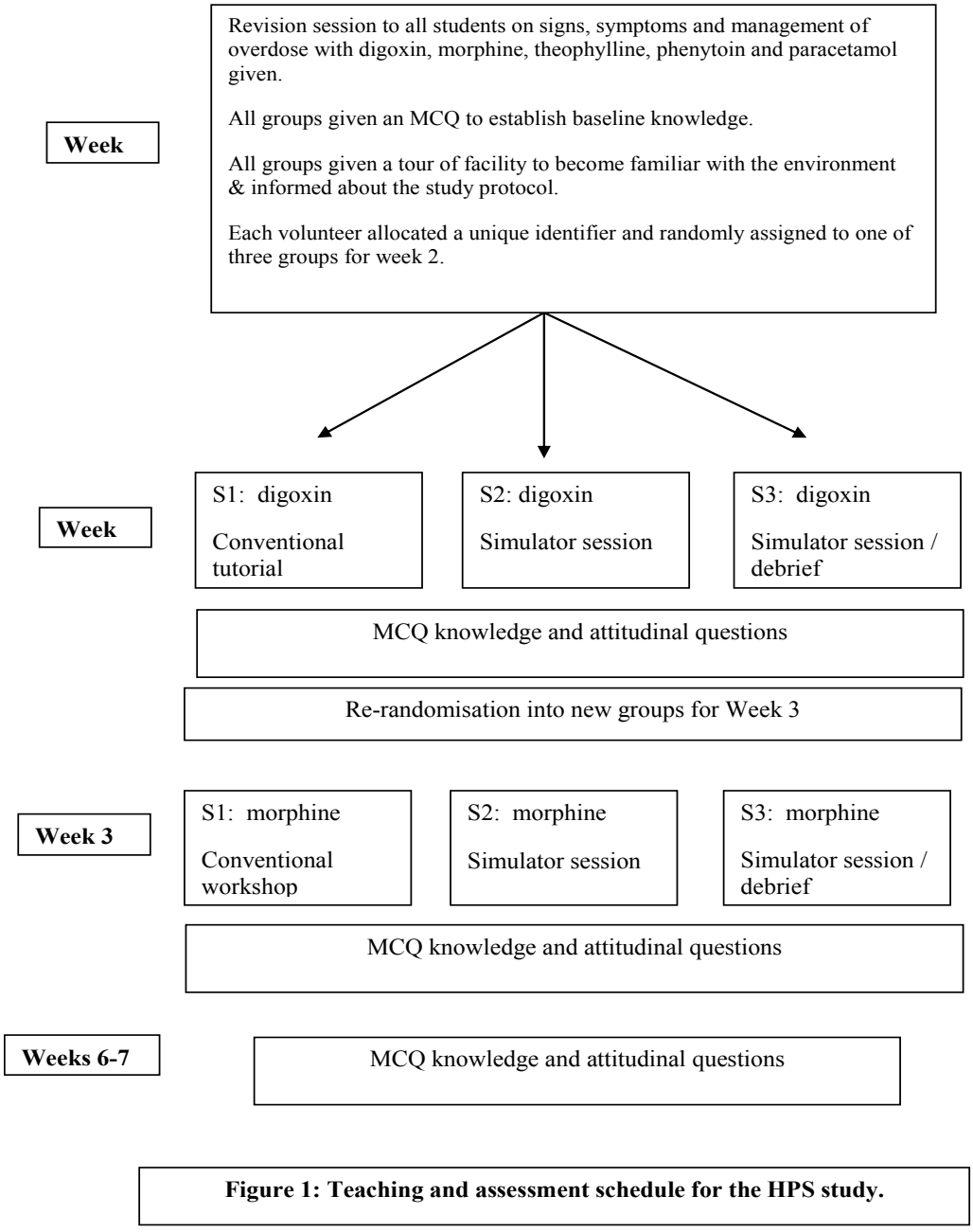

Figure 1: Teaching and assessment schedule for the HPS study.

appropriate and to ask questions. The second (S2) was a session involving the HPS. The third (S3) was similar to S2 above, but with an additional debriefing session, where students were allowed to discuss their experiences as a group after the HPS session. Discussions were led by the principal investigator (AR). Each session lasted approximately 40 minutes; with an additional 30 minutes in S3 for the debriefing session.

All S2 and S3 sessions were observed and videoed by ExPERT centre technicians to validate session conduct and capture additional data on student attitudes and interactions.

Scenario content

Two scenarios were chosen to reflect the type of material students would normally cover at Stage 3 of the MPharm and to exploit the potential for teaching using the HPS. A conventional revision session was delivered prior to the start of the study to ensure all students were aware of the underlying principles of managing drug overdose, a range of likely drugs, and the potential role of the pharmacist, without over-emphasising the two drugs used in the study itself (digoxin and morphine). These scenarios considered the signs, symptoms, diagnosis and subsequent management of drug overdose in a critical care setting. Both scenarios were checked by two experienced clinical pharmacists and a nurse with extensive Accident and Emergency Department (AED) experience, for currency of content and construct validity. The scheme for the morphine overdose scenario appears in Figures 2a and 2b using a standard ExPERT Centre HPS formatted script. The digoxin script, involving the management of severe overdose with Digibind, is available from the authors. All components of each HPS session were carefully scripted, rehearsed and piloted by the authors prior to delivery, including programming of the HPS and associated monitoring equipment and steps to be taken by the attending 'doctors' and 'nurses' when students made intervention recommendations; the latter were suitably dressed for the critical care environment. One was an experienced AED nurse and the other a qualified Operating Department Practitioner, who performed the required intubation in the morphine scenario; both also had extensive experience of HPS teaching with a wide range of other health care professional students. The only paper reference sources allowed for the teaching sessions were a copy of the current British National Formulary for both scenarios, and a copy of the Digibind Summary of Product Characteristics for the digoxin scenario.

Teaching was delivered to the three groups over three weeks as shown in Figure 1. Each group experienced all three teaching methods but in a different sequence to minimise bias.

Assessments

As indicated in Figure 1, students' knowledge of the topics delivered in the teaching sessions was assessed by closed book completion of a battery of multi-choice questions followed by some attitudinal questions to gain a sense of students' experiences and their opinions of HPS teaching in general. Spaces were provided for students to add their own comments. To ensure no contamination between sessions, different student groups were isolated when present in the ExPERT Centre at the same time. All assessments were undertaken on dedicated laptops, using the software package SurveyMonkey (Portland, OR).

To see what effect the teaching had on medium-term learning,

Figure 2a. HPS session for morphine overdose: scenario, requirements and instructor notes.

Setting the scene: student information	Equipment / supplies need	Instructor notes
This Scenario is written for Pharmacy students. *Location: ICU* **Patient:** Mr SDA, DOB 7.01.76, QA25905748 **Patient Presentation:** Stan is a 33 year old male, his hospital records list his only medical history as a compound ankle fracture requiring open reduction internal fixation (surgical use of plates and/or screws to fix a fractured bone), at that time he was given painkillers. Today he was rushed by ambulance to the hospital. He was given oxygen in the ambulance. He is currently unresponsive and is barely breathing. No history of prior illness. ***Allergies:*** NKDA ***Medications:*** Medical record not available. ***Social History:*** as above ***Secondary Assessment:*** 70kg; **Patient (Mannequin)** HPS	**Mannequin** Does NOT need to be primed **Equipment** Airway trolley for intubation O_2 Stethoscope BP Pulse Oximetry Monitor ECG leads Pen light Patient notes with correct name, DOB & patient history on front sheet Patient wristband **IV Supplies** Syringe of appropriate size labelled with Naloxone and strength.	Facilitator (AR) Doctor (PA) ICU Nurse (CL) HPS operator (LB) **Nurse / doctor script:** 'Bloods have been sent to the lab but we haven't got the results yet.' **Additional needs:** Need recording – HPS - Ward debriefing Laptops for MCQs in seminar room

Figure 2b. HPS session for morphine overdose: programme of events and desired student interactions and learning.

Facilitator	HPS State	Patient Status	Desired Actions	Desired group interactions / students learning
Facilitator introduces the scenario and relates history	Baseline (HPS)	HR=72 ABP=115/54 RR=15 SpO_2=98%	Students enter when in baseline **Transitions:** manual when facilitator starts reading patient synopsis	• actively engage with mannequin, doctor and nurse to find out relevant information concerning the patient. • recognize the signs & symptoms of morphine overdose. • correct choice of treatment: naloxone • correct calculation of naloxone dose • recommend naloxone,4-2mg repeated at intervals of 2-3 min to a max of 10mg if respiration does not improve. • recognise effects of recommended intervention
	Initial Presentation Morphine Overdose	HR=57 ABP=115/46 RR=8 SpO_2=92% T= normal Breath Sounds= reduced air entry on both sides		
	Intubation	HR=50 ABP=110/40 RR=6 SpO_2=90%	Doctor to intubate patient then explain to students why this is necessary. **Transitions:** manual after intubating.	
	Respiratory recovery	HR=80 ABP= RR=12 SpO_2=96%	Students state dose of naloxone to be given – administered by nurse **Tansitions:** manual after naloxone given	
	OD recovery	HR=72 ABP=115/54 RR=15 SpO_2=98%		

subjects were invited to complete a web-based MCQ test on both digoxin and morphine topics. These were conducted 3 – 4 weeks after completion of the teaching.

Statistical tests.

Before and after session scores were compared within groups using a paired t- test. Mean scores between groups were compared using analysis of variance.

Ethics approval

Approval for this study, including all teaching scenarios, assessment and debriefing sessions was obtained from the University of Portsmouth, ExPERT Centre Research Ethics Committee (Ref:8/3/09).

Results

Student knowledge

The mean scores for knowledge-based questions for the three groups before, and after each scenario are shown in Table 1. Each student was presented with 10 MCQs, each correct answer earning one point. Thus the maximum individual score in any MCQ test was 10. Only questions involving digoxin and morphine were scored from the baseline test.

With the first scenario (digoxin) the means of both the tutorial and HPS groups were statistically significantly greater than baseline. This was not the case with the HPS plus debriefing group; this group had a higher mean baseline mark. ANOVA analysis showed that the improvement was greatest with the conventional tutorial, which was statistically significantly improved compared to the HPS and debrief group, with the HPS only group lying between the two ($p=0.024$; R^2adjusted=33.09%).

With the second scenario (morphine) the post session means of all three groups were significantly improved over their corresponding baseline group scores. ANOVA revealed no significant differences between the means of the three groups ($p=0.243$; R^2adjusted=10.78%).

To investigate the effect of repeat exposure to simulation, a sub-analysis of results (increased mark from baseline) from those students who had taken part in two simulation sessions (both digoxin and morphine) was compared with those from students who had only participated in the first (digoxin). A two-samples t-test showed a mean improvement in mark over baseline of just over 2 marks in students who had experienced two HPS sessions; however this failed to reach statistical significance ($p=0.086$, 95% Confidence Interval: -0.467 to 4.68). This rather weak evidence does support the notion that students derive greater benefit from repeated HPS sessions (see student comments below).

Medium-term learning

The conclusions that can be drawn from this analysis are limited, due to the fact that several students (two in the digoxin group S2; and 2, 3 and 1 in the morphine groups S1,

Baseline (digoxin) Mean (SD)			**Digoxin Mean (SD)**			**Baseline (morphine) Mean (SD)**			**Morphine Mean (SD)**		
S1bd	S2bd	S3bd	S1d	S2d	S3d	S1bm	S2bm	S3bm	S1m	S2m	S3m
5.60	5.75	6.83	9.80	8.50	7.67	5.5	4.67	5.90	9.50	8.67	9.60
(0.96)	(0.94)	(0.52)	(0.45)	(1.05)	(1.51)	(1.00)	(0.58)	(1.43)	(0.58)	(0.58)	(0.89)
			Significance compared to baseline (P)						**Significance compared to baseline (P)**		
			<0.005	0.009	0.282				0.002	0.020	0.001

Table 1. Mean scores from knowledge – based MCQs administered at baseline and following each teaching session.

S1 = conventional tutorial session; S2 = HPS session; S3= HPS session with debrief
SD = standard deviation
bd = baseline digoxin

S2 and S3 respectively) did not complete the delayed MCQ test on SurveyMonkey.

Each of the digoxin groups performed similarly (ANOVA $p=0.18$; R^2adjusted=11.34%), although the mean for the HPS and debrief were lower (7.50) compared to that for HPS (8.83) and conventional tutorial (8.75) groups. These two means were still significantly higher ($p<0.05$) than baseline means obtained at the start of the study. Similar results were obtained for the morphine groups; there were no statistically significant differences using ANOVA ($p=0.162$; R^2adjusted=18.42%) with means for the three groups of 9.25, 8.33 and 9.40 respectively, all of which were significantly higher than baseline ($p<0.05$).

Student attitudes

Responses to attitudinal questions are shown in Table 2. It is clear that the majority of students who had experienced HPS had found the experience enjoyable, motivational, practical and personally beneficial. One student commented that: *'I think it's very relevant. Better than labs. I think it helps to make it more realistic and stick in our memory'*. Another stated that she thought *'..it is highly beneficial and a good way to incorporate hospital pharmacy into practice. It makes the teaching very real and I think it helps you to remember the knowledge better'*. Another said that HPS was: *'...good for people like me who learn more when taught in a hands-on, practical way'*. One student felt it was: *'...good to see what was happening first hand rather than reading about it.... It will make it so much easier to remember....'* Another said: *'It helped me identify my areas of weakness. I learned a lot of things that wouldn't be possible in lectures and seminars....It made me realise that there are other factors like cost, the relatives and other healthcare professional all of whom rely on you to make the right decisions'*.

Some students found the sessions stressful, probably due to their novelty and a minority had found them difficult. One student described being: *' ..worried at first but I then felt really happy by the end and it was a rewarding experience'*. Another said: *'It was stressful as you are under pressure, however once it is over you feel more confident that you have managed to work at what you do'*. One student stated: *'To begin with I felt anxious but once we had an idea of what was wrong, I felt more confident. I really enjoyed our scenario and it helped me to think more about the patient and family members'*. No student indicated that HPS was inferior to conventional teaching methods.

Clear majorities found the pace of the sessions satisfactory and their content realistic and relevant. One student commented that the session was *'.....very relevant as it mimics the hospital environment. I would feel more confident doing hospital pharmacy than before'*. and another thought: *'... it's very relevant to pharmacy teaching, especially in the clinical unit. It helps with skills such as group work and communicating with doctors, nurses and patients' relatives'*.

Discussion

Simulation permits deliberate practice and direct constructive feedback which has been shown to be vital for adult learning (Kneebone et al 2002). Students of all healthcare professions, including pharmacy may encounter the transitional problem of applying what they learn in the classroom or lecture hall to genuinely sick patients. Weller (2004) observed that they must learn to develop a systematic approach to such problems whilst learning to behave appropriately as part of the clinical team and that HPS helped to bridge the gap between theory and practice in a controlled setting.

It is important with any new teaching environment, to familiarise students with the new surroundings. This is particularly relevant with HPS where every attempt was made to replicate an ICU setting. In our study, students were given a lengthy tour of the 'ward' by the ExPERT Centre technicians and allowed to ask any questions that came to them about the equipment and the possible signs and symptoms displayed by the HPS and surrounding monitors.

Practically, HPS in the settings used could only be delivered to a small group of students (in this case six) at any one time. This does reflect real world, near-patient teaching where small groups of students would be introduced to a case on a ward or in ICU.

It should be noted that the improved performance after the HPS, and HPS with debrief, groups undertaking the morphine sessions may have been influenced by increasing familiarity with the HPS. This was not seen with the digoxin sessions;

Statement	Strongly agree %	Agree %	Disagree %	Strongly Disagree %
With respect to incorporation of HPS into the MPharm do you feel it would be:				
Time efficient	25	55	20	-
Realistic	50	50	-	-
Convenient	50	40	10	-
Relevant	95	5	-	-
I personally think the HPS method of teaching was:				
Embarrassing	-	15	60	25
Enjoyable	65	35	-	-
Motivational	75	25	-	-
Stressful	-	50	45	5
Beneficial to me	50	50		
Difficult	5	25	30	40
Practical	55	45	-	-
No better than conventional methods	-	-	35	65

Table 2 – Responses to attitudinal questions from those students experiencing HPS (n=20).
Data represent an amalgamation of responses from both HPS alone and HPS plus debrief students who had undergone at least one of the HPS sessions. Where students had undergone two HPS sessions due to randomisation, the second set of replies was considered.

indeed, the conventional tutorial technique produced significant improvements from baseline in both scenarios, perhaps because students were familiar with this technique and the lecturer concerned (DB). The results show that students who undertook more than one HPS session tended to do better than those who did only one. One student supported this by saying: *'I felt more relaxed the second time around as I was more prepared for what the situation would be like. I felt it much more beneficial having more than one session with HPS'* This indicates that in designing an HPS programme, thought should be given to providing an introductory 'scene setting' session to familiarise all participants with the methodology before embarking on the real meat of a particular module.

In most schools of pharmacy, HPS is a novel technique and as with the present study, it would not be surprising if both staff and students take some time to become familiar with the process.

We considered it important to determine the students' attitudes to HPS. Experience with other students has shown that not all will take to the environment and watching the consequences of their recommendations being acted out, even in a mannequin. This is particularly true with pharmacy students who may have had little near-patient experience, especially in a critical care setting. It was notable that the clear majority of students responded favourably to the methodology.

Use of the HPS in our study ensured high physiological fidelity; however, Maran & Glavin (2004) have pointed out that to be truly effective, the simulation session needs to possess high psychological fidelity also. The latter describes the degree to which the skills required by the student are captured in the simulated scenario. We believe that both fidelities were achieved in our two scenarios after careful design and input from practising nurses and clinical pharmacists.

It was clear from watching recordings of the HPS sessions and during debriefing and from the findings presented above, that the sessions triggered reflection, questions, and group discussion of the cases being simulated which the tutorial sessions did not. It is unclear why the debrief session did not produce more favourable results for both scenarios; perhaps this was simply an artefact of the small group numbers involved. It might also have been due to students' unfamiliarity with this particular aspect of teaching. Certainly the debrief session is recommended by experienced users of HPS (Key-Dismukes *et al*, 2006). This aspect will be investigated further in subsequent studies.

HPS teaching is costly. Rolling out sessions to all undergraduate students would demand considerable teaching and technical staff time (repeated sessions for large groups; scenario scripting and development) and overheads (e.g. HPS maintenance). With such limitations, it may be that HPS will only ever find a place in specialist teaching, for example in a critical care elective.

The very challenging clinical scenarios presented to the students may have resulted in less knowledge gained. Intuitively, using less stressful ones, such as the routine clinical screening in critical care, may improve overall learning and allow greater group sizes. This is a topic for future research.

It should be remembered that all students who participated in the study were volunteers who by definition, had an interest in this area. We intend to reflect on the findings and investigate ways of introducing HPSs so that more students can benefit at different stages of the course.

Conclusions

This small pilot study failed to show conclusively that HPS, with or without the presence of a debriefing session, was superior to conventional teaching methods in the critical care setting, in terms of improving knowledge. However, teaching

is not just about instilling knowledge. It is also about providing a quality learning experience and developing skills such as critical thinking to solve problems as individuals or as a team. Feedback from participants was strongly positive in these respects.

However, simulation has also been shown to provide an opportunity to examine a number of non-technical skills such as communication, teamwork and situational awareness and with an effective debriefing session, to develop into a reflective practitioner. We plan to evaluate these aspects of HPS teaching in future studies.

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