Introduction
Clinicians as educators are expected to engage undergraduate students in meaningful ways and promote accurate knowledge, skills and attitudes required for treating patients. While every effort is taken during students’ undergraduate curriculum to expose them to patients with serious conditions, due to the sheer volume of the curriculum and the number of students, it is not possible to ensure every student experiences every ‘serious’ condition in actual clinical practice. Other methods to promote blended learning include e-learning modules and problem-based learning workshops; however, these lack the fidelity of student–patient interaction. Tomorrow’s Doctors states that students are expected to ‘assess and recognise the severity of a clinical presentation and a need for immediate emergency care.’¹ One such condition that medical school graduates are expected to be aware of and know how to manage is diabetic ketoacidosis (DKA).

DKA is arguably the most critical short-term complication of diabetes and is characterised by a triad of symptoms (hyperglycaemia, ketosis and acidosis) which can lead to coma and death. In NHS Scotland a marked rise (~58%) in the incidence of DKA was observed from 2003/4 to 2011/12 across the lifespan in those with type 1 diabetes.²,³ Although mortality rates have fallen significantly in the last 20 years from 7.96% to 0.67%, unfortunately errors in its management are not exceptional and crucially are associated with significant morbidity and mortality.⁴,⁵

Over the last decade or so, simulation technology has been playing an ever more important role in both undergraduate and postgraduate medical education as low-frequency, high-acuity conditions can be accurately simulated allowing student/doctor exposure to these conditions in an active learning environment. Simulation allows students and practitioners to move up Miller’s pyramid from ‘knows how’ to ‘shows how’⁶.

The aim of this paper is to describe the development of a multi-task based high-fidelity simulated DKA scenario which educators in other institutions can utilise and develop for teaching thus allowing the student opportunity to ‘show how’ they would manage this emergency. We plan to demonstrate the associated learning outcomes such a scenario provides for undergraduate students, mapped against key educational domains. We will then discuss other potential future learning outcomes for other...
health care professionals and more senior doctors from a simulated DKA scenario.

Methods
A simulated DKA scenario, as taught at the University of Aberdeen for undergraduate medical students, will be described. The expected learning outcomes in terms of knowledge, skills and attitudes will be defined as mapped to key educational domains.

Scenario
The simulated scenario is delivered to pairs of final year students in the simulation suite at the University of Aberdeen.

Pre-scenario students are briefed and orientated to the simulation suite and a discussion of learning needs and objectives occurs prior to the simulated experience. Students are reminded that they should perform tasks as they would in real life and treat the manikin as a real patient. The scenario has been developed to concentrate on the first hour of management of a patient with DKA.

Students are told that their task is: ‘You are the FY doctor working in the Acute Medical Initial Assessment (AMIA) department of your local hospital. This patient has been sent in by their GP with a three-day history of vomiting. You have been asked to see them.’ They are given an SBAR\(^7\) (Box 1) handover.

Students then enter into the simulation suite where SimMan (Laerdal, Norway), a mid-fidelity simulator manikin, has been set up, with no monitoring on as yet. They are viewed via a one-way glass screen and also via SMOTS (Scotia, UK) video monitoring, allowing for recording of the consultation (Figure 1).

The simulation technician/practitioner has already been briefed with the following observations to simulate when the appropriate monitoring is attached (Table 1). Students speak to the manikin and interact as they would with real patients in a clinical encounter; they are expected to perform a number of tasks as they would in the management of a real-life unwell patient such as focused history taking, clinical examination, application of monitoring as well as various procedural skills, intravenous access, urine dip, fluid prescription etc. Figure 2 shows the storyboard of expected procedures. Figure 3 shows in diagrammatic representation the tasks expected to be performed as mapped to key educational domains.

These baseline characteristics can be altered in response to interventions that participants perform or can deteriorate to make the scenario more complex depending on which group is performing. Figure 2 outlines the practical procedures which are expected to be performed during the scenario. Our equipment includes low-fidelity arterial blood gas and cannulation arms.

Following scenario conclusion, students are debriefed by the

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**Box 1.** The SBAR (Situation, Background, Assessment and Recommendation) nursing handover given to participating students

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**Table 1.** Baseline simulation parameters for diabetic ketoacidosis (DKA) scenario

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial setting</th>
<th>Expected student performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airway</td>
<td>Talking in short sentences</td>
<td>Focused history taking</td>
</tr>
<tr>
<td>Breathing</td>
<td>SpO(_2): 93% on air. Respiratory rate 36/min (Kussmaul). No added sounds</td>
<td>Application of correct O(_2) and monitoring</td>
</tr>
<tr>
<td>Circulation</td>
<td>Heart rate 130bpm. BP 90/70. Capillary refill time 4s</td>
<td>Monitoring, IV access, fluid prescription and administration, blood test sampling</td>
</tr>
<tr>
<td>Disability</td>
<td>Glasgow Coma Score 15. Capillary blood sugar ‘Hi’. Pupils equal and reactive. No drug chart</td>
<td>Diagnose DKA, urine dip (or blood ketone stix), venous or arterial blood gas. Refer to DKA protocol; prescribe insulin and IV fluids</td>
</tr>
<tr>
<td>Exposure</td>
<td>Temperature 37.2. Occasional vomiting noises</td>
<td>May prescribe antiemetic. Search for cause of DKA</td>
</tr>
</tbody>
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**Figure 1.** Demonstrating operational control centre, SMOTS video recording (left-hand monitor), SimMan control (laptop) and scenario participants through one-way glass
clinician responsible for the scenario and, if available, by the simulation technician and practitioner. We utilise video playback during these sessions whereby students can see their performance at strategic time points. We explored utilising a further delayed debrief, whereby students could watch the whole recording of their session, two weeks following the scenario against a structured checklist based on the Scottish DKA ‘care pathway one’ protocol.8 These debriefs allowed discussion of both clinical aspects of DKA management as well as non-technical aspects, patient safety parameters and potential pitfalls in DKA management.9

Aspects covered in the debrief can include the differential diagnosis, the difference between DKA and hyperosmolar hyperglycaemic state, what provoked this episode of DKA, and other concurrent problems such as alcohol or drug use. Reviewing admission documentation and the patient drug list along with the safe prescribing of insulin was another beneficial area. The importance of continuing background insulin to minimise the chance of re-DKA can be explored and ongoing management and patient education of sick day rules discussed. Many patients are now on continuous subcutaneous insulin infusions (CSII) and potential cannula or pump problems can be highlighted. The importance of blood ketone measurement as opposed to urinary ketones can be reviewed depending on the student’s actions during the simulation scenario. All of the above or specific issues in the debrief can be addressed depending on the student’s training needs.

Initial feedback from the pilot group was positive with the most useful aspect of the simulation stated as being given the opportunity to manage an acutely-ill patient and perform a number of practical procedures.

**Discussion**

Much work has been done focusing on the challenges of transitioning from medical student to practising junior doctor. As such, undergraduate curricula are being developed to introduce early and meaningful patient contact.10 However, all undergraduate students cannot be expected to witness and participate in the management of all critical illness. Many students do not see DKA in real-life patients and, while they may have the knowledge from lecture based educational methods, they may not have the necessary diagnostic and management skills as expected of a practising doctor. The use of simulation in medical education now allows increased exposure of low-frequency, high-acuity events with students being able to translate guidelines into practice. This scenario has been designed around the current Scottish DKA clinical guidelines, which we utilise in our health board, NHS Grampian.8

The scenario is mapped to core educational domains (Figure 3) allowing students to practise key tasks involved in the diagnosis and management of DKA. The structured debrief is a key component to the simulation experience allowing for appraisal of knowledge, skills and attitudes shown during the exercise. It allows for further tutor facilitated discussion regarding potential pitfalls in management of DKA including potassium prescribing and replacement, fluid management, levels of care and management of cerebral oedema.9 One particular educational need identified from our experience is that of insulin prescribing and selecting the correct formulation of insulin for use in DKA. Reviewing the insulin prescription allows time to reflect on documentation, insulin regimens and delivery devices including CSII. This is a major patient-safety issue as outlined by Lamont et al. in a summary of a safety report from the National Patient Safety Agency.11
While in our example the scenario was delivered to senior medical students, adaption of this scenario would be easy and allow for teaching of experienced medical staff or a multi-professional scenario with allied health professionals including nursing students or postgraduate staff. While no formal cost analysis has been performed on this project most UK medical schools have the necessary equipment to provide high-fidelity simulations with the only additional costs being disposable equipment and practitioners’ time.

Other aspects of the debrief highlight practices in non-technical skills and communication, as well as discussion and reflection on data obtained by psychology colleagues following DKA admission. As well as the students’ self-reflection and reflection from educators, additional information on the scenario can be gained from a psychologist trained in identifying behavioural and cognitive skills needed to manage DKA in an acute hospital setting. By identifying specific, observable behaviours (both effective and ineffective) they can support evaluation and reflection, as well as giving areas for future training or education. Admission for DKA is associated with a complex and clinically significant psychological reaction. It is therefore crucial

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Figure 3. Scenario mapping to core educational domains. (SEWS = Scottish Early Warning System; ECG = electrocardiography; ABCDE = airway, breathing, circulation, disability, exposure)
that medical students are aware not only of this, but also of the need to modify their behaviour accordingly during the clinical scenario; e.g. this could be observed by monitoring patients’ symptoms of anxiety.

Our scenario was conducted in the simulation suite of the University of Aberdeen Clinical Skills Department. The introduction of mobile equipment now allows for scenarios to be performed in the ‘workplace’. This would have added benefits as staff would be working in their usual environment, in their usual clinical teams with their usual equipment, and allows for another area in which this teaching and learning experience can be developed.

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Declarations of interests

There are no conflicts of interest declared.

References