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Five years' experience of simulation-based learning in the therapy of serious infections: Student satisfaction and learning outcomes

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Simulation-based learning (SBL) offers students effective learning opportunities to practice and develop clinical skills but can be challenging to maintain long-term. For this study, we developed authentic video simulations requiring clinical decision-making regarding appropriate antibiotic selection, to enrich the learning experience for students; and evaluated their impact on student learning and satisfaction. Two scenarios (tuberculosis and polymicrobial infection) were developed with expert input and filmed using professional actors and a small film crew. Between 2019 and 2024, second-year pharmacy students participated in SBL activities utilising the videoed scenarios. Evaluation was via pre- and post-tutorial questionnaires. Over a five-year period, pre- and post-activity questionnaires were completed by 233 students (62.5%) for tuberculosis and 275 (54.9%) for polymicrobial infection. Statistically significant differences between pre- and post-tutorial questionnaire scores were observed. Most students reported the SBL activities were outstanding/excellent (80.0-93.6%) and helped them to acquire critical thinking skills (mean: 90.1% tuberculosis; 93.2% polymicrobial infection). Positive outcomes were consistent across the five-year timeframe. SBL activities involving video simulations were a sustainable approach to enhancing students' learning experience, and supported consolidation of knowledge about antimicrobial agents and practice of clinical decision-making skills in selecting appropriate antibiotics to treat infectious diseases.

Keywords: simulation-based learning, healthcare professional education, polymicrobial infection, student satisfaction, antimicrobial agents

Introduction

Simulation-based learning (SBL) has been applied to many facets of healthcare professional education, providing students with an effective opportunity to develop and practise their clinical skills (Al-Worafi, 2023; Motola et al., 2013). This mode of learning utilises objective-driven role-play with a simulated patient to replicate the clinical setting with no risk to a real patient (Cant & Cooper, 2017; Roh et al., 2018). SBL engages students by involving them in case studies, having them actively role-play as the healthcare professional to practice real-world skills such as information gathering, patient assessment and clinical decision-making.

In recent decades, the role of pharmacists has become more complex, with a greater emphasis on patient-centred care (Korayem, 2022). Practice in real-life environments without guidance can be overwhelming for students and can involve unprecedented risks to the patient (Weller et al., 2012). In addition, real-life situations do not provide enough practice opportunities, for example, critical situations during clinical placement may be limited and ethical risks may be involved (Weller et al., 2012). SBL in pharmacy education has been shown to enhance students' acquisition and retention of fundamental knowledge, improve learner confidence, enhance clinical performance, encourage critical thinking, and decrease medication misadventure (Kuesakul et al., 2024; Seybert et al., 2019). Practicing skills like gathering patient information, sharing information with interprofessional colleagues clinical decision making, critical thinking, resolving conflict, or giving clear health advice in SBL scenarios helps students develop teamwork and communication skills, leading to better patient outcomes (Lee et al., 2021). SBL has therefore become embedded throughout the learning journey for pharmacy students to accommodate a growing need to develop and refine their clinical skills in a safe environment (Korayem et al., 2022). In pharmacy education, SBL is primarily grounded in experiential learning theory, with influences from situated learning theory and cognitive load theory (Korayem et al., 2022; McBane et al., 2023).

Antimicrobial Chemotherapy challenges second-year Bachelor of Pharmacy Honours students with a content-heavy syllabus. It requires acquisition and retention of knowledge regarding pharmacology, spectrum of activity and pharmacokinetics of antimicrobial drugs, as well as application of this knowledge to the selection of appropriate therapy, within a 12-week teaching semester. Most students are still relatively early in their tertiary academic careers, with little experience in the clinical setting, having completed limited clinical pharmacy placements. Both factors impact relatively low unit pass rates (e.g. 88% in 2018).

This study took place at Curtin University, Perth, Western Australia and recruited second-year students enrolled in *Antimicrobial Chemotherapy*. Recognising that there are a number of challenges identified to the use of SBL, such as resource-intensiveness (cost), sustainability and staff training (Singh et al., 2023), we sought a solution that was feasible, sustainable and suitable for integration into the curriculum.

Guiding research questions

RQ1) What impact, if any, do SBL activities related to infectious diseases have on students' clinical decision-making skills and learning experience?
RQ2) How sustainable are realistic SBL activities and can they be integrated into the curriculum?

Study context

An authentic SBL approach, based on experiential and situated learning theory, with elements of cognitive load theory, was developed to increase student engagement, offer students opportunities to apply their knowledge and build clinical decision-making skills essential to real-world practice. This paper describes the development of the realistic simulated scenarios, their integration into a second-year Bachelor of Pharmacy Honours unit and the evaluation of the learning outcomes and students' satisfaction with the SBL activities.

Methods

The study was granted ethics approval by the Curtin University Human Research Ethics Committee (Approval number: HREC2019-0368) on 17th June 2019. The intended learning outcomes of the tutorials were to consolidate students' understanding of the mechanism of action, adverse effects and spectrum of activity of antimicrobial agents and to practice appropriate antibiotic selection based on laboratory and evidence-based resources. To achieve these outcomes, SBL activities with integrated videos of authentic clinical scenarios were introduced to tutorials. Drawing on experiential learning theory, two SBL scenarios were developed – a primary care-based scenario involving a simulated patient with tuberculosis and a hospital-based scenario (emergency department and hospital ward) involving a simulated patient with diabetes and a polymicrobial foot infection. These two topics were chosen because: (1) their relative clinical complexity, in that their management involves multiple antimicrobial agents; and (2) they allowed explicit demonstration of the incorporation of patient-specific factors into clinical decision-making.

A script was developed for each scenario with expert input by academics (four academic pharmacists with clinical practice experience and a practicing biomedical scientist), as well as an antimicrobial stewardship pharmacist. For the hospital scenario, simulated inpatient clinical progress notes, a medication chart and diabetes chart were developed. A moulage of a simulated wound was purchased to resemble the diabetic foot infection. Each scenario was filmed using professional actors and a small film crew. Filming occurred in a simulated primary care setting (tuberculosis) and simulated hospital ward (polymicrobial foot infection) (Figure 1). The overall polymicrobial foot infection and tuberculosis videos were of 11.17 and 10.03 minutes duration, respectively. Each video was broken up into four separate videos at suitable time points, to allow for in-class discussion, which situated the student in the role of the pharmacist caring for the patient, aligned with situated learning theory. Each scenario tracks a patient's journey from diagnosis to management and final outcome, while the presentation as four short videos manages cognitive load. For example, the first polymicrobial foot infection video shows the patient in the emergency department, discussing her condition with a doctor and having a wound swab taken. The second video shows her in a hospital bed later that day, discussing preliminary test results. In the third video, 14 days later, she is informed that surgery is needed to

amputate the affected area. The final video, the day after surgery, sees the patient listening to an explanation of why antibiotic therapy failed due to an unexpected hospital-acquired methicillin resistant *Staphylococcus aureus* infection.

Development of questionnaire and evaluation

All students enrolled in *Antimicrobial Chemotherapy* in Semester 2 in 2019, 2022, 2023 and 2024 were invited to participate in the SBL activities as part of the tutorial program and to evaluate these activities via a questionnaire. Due to face-to-face restrictions associated with the Covid-19 pandemic, the SBL activities were not delivered in 2020 and 2021. Separate pre- and post-tutorial questionnaires were developed for each scenario. The pre-tutorial questionnaire gathered demographic data and included 10 knowledge-based questions. To evaluate the learning outcomes of the activities, the post-tutorial questionnaire consisted of 10 knowledge-based questions, which were different to questions in the pre-tutorial questionnaire but addressed the same learning outcomes. The post-tutorial questionnaire also included an evaluation of the SBL activity. The evaluation survey consisted of one multiple-choice question and fourteen Likert scale response statements (strongly agree, agree, disagree, strongly disagree, undecided/not applicable).

Tutorial format

The flow of the tutorial format is summarised in Figure 1. During each tutorial, students watched the four short videos, each followed by a discussion. In addition, for the polymicrobial hospital-based scenario, all students received relevant documentation related to the scenario (clinical progress notes, a hospital medication chart, the medication history and management plan, and an insulin and blood glucose chart). This provided students with an opportunity to analyse, review and interpret the documentation in the context of the scenario they had observed. Students then discussed treatment options with tutorial group members and made clinical decisions and treatment recommendations based on this information.

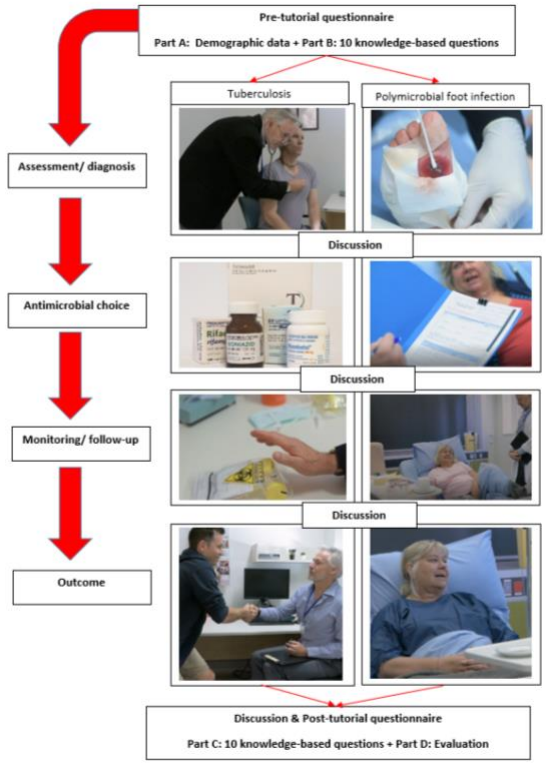

Figure 1. Sequence of events for each 2-hour simulation-based learning activity

Statistical analysis

De-identified data were entered into IBM SPSS Statistics for Windows, Version 29.0.0.0 (Armonk, NY: IBM Corp) for analysis. Simple descriptive statistics (frequencies and percentages for categorical variables; means and standard deviations for variables measured on a continuous scale) were used to summarise the data. Pre-tutorial and post-tutorial test results were compared using paired Student's t-tests. The a priori level of significance for all statistical tests was set at P <0.05.

Results

The response rate for the pre- and post-activity questionnaires was 62.5% (233/373) for tuberculosis and 54.9% (275/501) for the polymicrobial infection. The majority of respondents were female, aged between 20-25 years and studying full-time. Most students reported the tuberculosis (80.0-98.2%) and polymicrobial infection SBL activities (82.1-93.6%) were outstanding or excellent (Figure 2), with little variation between the two tutorials or across the five years of the evaluation. Table 1 shows the mean and SD score (out of 10) for the pre- and post-tutorial knowledge-based questions. The mean paired differences between the pre- and post-tutorial scores for the polymicrobial infection tutorials were approximately one mark out of 10 (0.6±1.7 to 1.4±2.5) in each year it was delivered, except in 2024 when the mean difference was 4.1±1.9 marks; all differences were statistically significant. For the tuberculosis tutorial, the mean paired differences were 0.5± 2.2 in 2019 (p=0.062), 1.2±1.7 in 2022 (p<0.001) and 5.2±2.0 in 2024 (p<0.001).

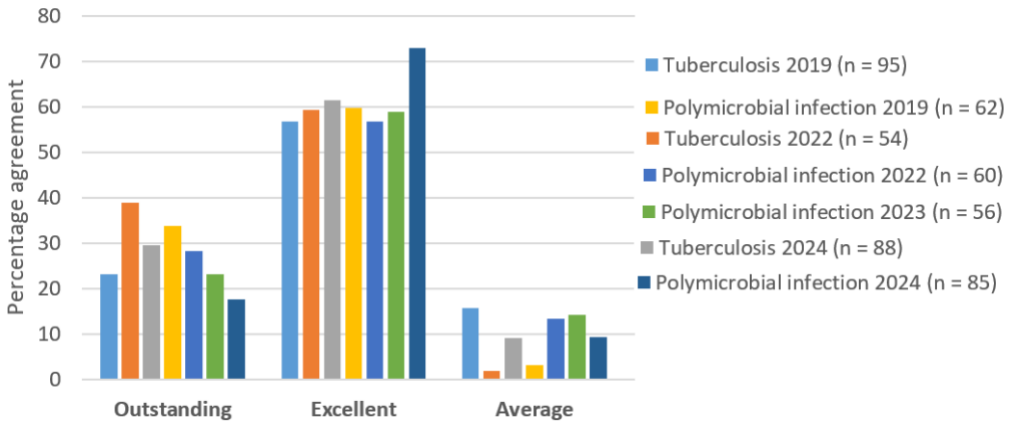

Figure 2. Students' experience of the tuberculosis and polymicrobial infection SBL activities

Table 1
Pre- and Post-questionnaire Data for the Tuberculosis and Polymicrobial Infection SBL Activities

Year	Number of students enrolled in the unit	Number of students who completed the activity	Pre-tutorial data	Post-tutorial data	p-value
			Mean	Mean	
Tuberculosis SBL					
2019	123	85	7.19 ± 2.079	7.65 ± 2.240	0.062
2022	112	60	4.95 ± 1.799	6.12 ± 1.992	<0.001
2024	138	88	3.78 ± 1.631	8.98 ± 1.508	<0.001
Polymicrobial infection SBL					
2019	123	74	5.41 ± 2.119	6.77 ± 2.058	<0.001
2022	112	60	4.95 ± 1.799	6.12 ± 1.992	<0.001
2023	128	56	5.64 ± 1.667	6.20 ± 1.542	0.017
2024	138	85	3.49 ± 1.770	7.60 ± 1.699	<0.001

There was a high level of agreement (strongly agree/agree) for the fourteen Likert-based statements over the study duration for the tuberculosis and polymicrobial SBL activities. For both SBL activities, more than 90% of respondents agreed that the session held their interest and that overall, they were satisfied with the learning experience. Most students reported the SBL activities helped them to acquire critical thinking skills (mean: 90.1% for tuberculosis and 93.2% for polymicrobial infection). Participating students reported the SBL sessions were useful to help them learn better (mean: 95.2% for tuberculosis and 97.7% for polymicrobial infection), and almost all (93.6-95.0%) agreed that they would like more SBL activities to support their learning in the future. Positive outcomes were consistent across the five-year timeframe.

Conclusion

This study identified that SBL activities involving video simulations of infectious disease scenarios can help students develop clinical decision-making and critical thinking skills, positively impacting their learning experience. Our approach proved a resource-conscious approach that has demonstrated longevity and sustained positive outcomes. We acknowledge that the observed student learning outcomes are attributable to the multifaceted tutorial experience, rather than SBL in isolation. However, building on our results, integrating the high-quality videos into a game-based learning platform presents an innovative opportunity to further engage learners through interactive patient journeys and gamified assessments, ultimately supporting the education of future health professionals in responsible antibiotic use and antimicrobial stewardship.

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ASCILITE 2025

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