# Simulation-Based Instruction for Pharmacy Practice Skill Development: A Review of the Literature

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## Abstract

**Background:** Simulation is attractive for its potential for applying a control over learning environment, content complexity, teacher time, costs and risk. Simulation-based instruction (SBI) is poised to expand in pharmacy practice and education. This systematic review synthesises published, SBI in first-degree pharmacy programmes, especially those pertaining to psychomotor or cognitive skill development. **Materials and Methods:** MEDLINE, Cumulative Index to Nursing and Allied Health Literature, and some education journals were searched for relevant articles published between January 2000 and December 2015. **Results:** Of 108 articles identified, 12 were included, which were covering four major simulation-based interventions. These simulation-based interventions were diverse, and they covered a range of competencies and outcome measures. Nine studies included medication, and five studies included physical examination/procedure-related competencies as outcome measures. The evidence from nine studies suggested that skills could be improved through interventions involving human patient simulation. **Conclusion:** Despite improvements in students' ability to perform, there is a lack of evidence on how this translates to real settings and to patient satisfaction.

**Keywords:** Cognitive, instruction, pharmacy, psychomotor, simulation, skills

## Introduction

The role of patient care pharmacists is primarily focused on optimising therapeutic outcomes, particularly from pharmacotherapy perspective. Pharmacists are professionally obliged to secure safe, effective and responsible use of medicines by patients, prescribers and populations.[1] The essential role of pharmacy education is to produce competent, ethical, empathic and work-ready graduates. Thus, educators and policy makers must view pharmacy education from the standpoint of *fitness for purpose* for current as well as evolving, anticipated or aspirational roles and responsibilities.[1]

The goals of clinical education and training can be achieved in real patient care settings, via simulation or a combination of the two. As authentic and rich learning environments, patient care settings provide situated learning, but less control is possible over content than that in a classroom: opportunistic learning can be a limitation, particularly for novices. Other key characteristics of patient care settings that may negatively impact learning are their 'messy' nature, competing demands on clinician-teachers and risks associated with entrusting professional activity to students. Simulation has been defined as '(an) event or situation made to resemble clinical practice as closely as possible'.[2] Simulation-based instruction (SBI) is used in pharmacy education.[3-5] For example, pharmacy education in the United States has employed simulation-based learning for more than a decade.[5,6] This has included the use of standardised patients, role-play and skills assessment.

Simulation is attractive for its potential for applying a control over learning environment, content complexity, teacher time, costs and risk. Simulations offer progressive, scaffolded learning in safe, convenient, comfortable, yet convincing learning environments.[7,8] Depending on the simulation, there is a low or controlled risk to patients, while enabling the improvement of skills that will help protect patients.[8]

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Simulation-based learning has consistently produced positive outcomes in terms of improvements in knowledge, skills and behaviours.[9,10] However, the departure from reality can be limiting in itself, and for example, in the potential to inculcate empathy and care-related traits and values through interaction with patients. Intelligent instructional design can, thus, exploit the advantages of both simulation and real patient care settings. Hicks *et al.*[11] investigating the effect of high-fidelity simulation on nursing students' knowledge and performance, found that students in a combined simulation/clinical experience group had highest scores in knowledge retention and clinical skills. The authors suggest that the most effective teaching methodology is a combination of simulation with direct patient care experience.

The concept of experiential learning, a key element in medical and pharmacy education is getting complicated, costly and impractical in certain regions of the world. Challenges that make it difficult for students to gain real-world experience include increasing patient insight, a growing emphasis on patient protection, decreased faculty resources, and competition for clinical teaching sites. Thus, more institutions are now implementing simulation-based active and adult learning theories and concepts in different parts of the world. In the US, the Accreditation Council on Pharmacy Education has approved the use of simulation in Introduction to Pharmacy Practice Experiences for up to 20% of the total experiential education requirement.[12]

One of the most commonly implemented simulations is the use of standardised patients, who are volunteer individuals trained to act as patients. Generally, standardised patients are required to present history, exhibit emotions and project personality.[13] Standardised patients are readily available, and their use is more economical than the use of technically advanced simulation such as high-fidelity patient simulators or mannequin.[14] The most important limitation of simulation is that it is not real. However, the success of any simulation-based intervention depends on the level of student engagement and participation. Where there is full engagement and commitment to the simulation, participants benefit from the learning experience.[14]

SBI is generally used in cognitive (knowledge) and affective (communication) domains. However, SBI can also cover high-order learning and the psychomotor domain.[6,15] There is growing body of evidence for the usefulness of SBI in improving psychomotor skills in undergraduate pharmacy education.[5] Previous reviews have addressed similar issues but not focussed on psychomotor skills.[6,14] We evaluated published evidence to determine which instructional formats were effective in improving psychomotor skills, and to identify gaps in the evidence to inform future research. To the best of our knowledge, this is the first review of the use of simulation-based teaching strategies for developing clinical pharmacy skills. The purpose of this review is, thus, to evaluate the usefulness of SBI for skills application, enhancing performance and improving confidence among pharmacy students.

## Materials and Methods

### Scope of review: eligibility criteria

We screened abstracts for articles published in English (a) addressing simulation and skills, (b) reporting performance-based or skills-based findings and (c) reporting skills assessment and/or outcome measures. We excluded studies focussed on assessing knowledge; cognitive and affective assessment and evaluation of student satisfaction with simulation-based learning. We included longitudinal studies, those measuring pre- and post-simulation performance, and post-simulation performance.

### Information sources

MEDLINE, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and some education journals were searched for relevant articles published between January 1, 2000 and December 31, 2015. Reference lists were scanned for additional potentially eligible publications. These were put through the same eligibility evaluation.

### Searching

Our search strategy identified a research on simulation-based interventions involving pharmacy students. Search terms were constructed using a population (P), intervention (I) and outcome (O) model that took the following form: ' (pharmacy student* OR final-year* OR senior pharmacy student*) AND (simulation/simul*) AND (psychomotor skills OR performance-based OR competency-based OR instruction-based OR clinical pharmacy skills OR clinical pharmacy training OR clinical experience* OR pharmacy practice experience*)'. Titles and abstracts were screened to remove studies that were clearly irrelevant to the aim of the review. The full texts of the remaining studies were then examined to determine eligibility.

### Study selection

After possible studies were identified, all retrieved titles were screened by one of the four investigators to decide whether titles appear potentially relevant to the study area. Two investigators assessed the abstracts independently against four criteria: (i) studies involving SBI; (ii) psychomotor or cognitive skill development; (iii) any study design and (iv) included pharmacy students from any year of study. We included studies on pharmacy students, in any year of study, undertaking first-degree programmes leading to eligibility for professional registration with national pharmacy regulators. Globally, these are primarily Bachelor of Pharmacy (BPharm), Doctor of Pharmacy (PharmD) and Master of Pharmacy (MPharm) programmes. We clarified any ambiguity with authors. Full papers from potential studies were assessed independently by the two investigators for their suitability.

### Data collection process

One investigator extracted data on a data extraction form (in table format). Another reviewer checked extracted data. Abstracted data included the name of the first author; country; publication year; study design; number of subjects; type of intervention; description of intervention; outcome measured and impact of intervention [Table 1]. The purpose, study design, number of participants, description of intervention, outcome measures and validity together with reliability of outcome measures were recorded. The impact of interventions reported by the included studies was also presented.

### Data items/study characteristics

Intervention: We assessed simulation-based interventions aimed at improving psychomotor skills. These interventions potentially included: simulation with real patients; human patient simulation; use of electronic medical records (EMRs) and use of standardised or simulated patients.

Outcome: Outcome measures included medication-related outcomes (e.g., device technique), medical record utilisation and patient-related outcomes [e.g., blood pressure (BP) monitoring]. Studies were included if they reported at least one primary outcome measure or at least one secondary outcome measure.

### Quality assessment

Each included study was evaluated against a quality checklist to estimate a quality index that would serve to rank the studies. Two review authors assessed the internal validity of each included study. Each included observational study was evaluated against a quality checklist for observational studies to rank studies in terms of deficiencies.

## Results

### Search results and study characteristics

The search yielded 77 unique abstracts from MEDLINE, 23 unique abstracts from CINAHL, and eight from pharmacy and medical education journals. Of these, 65 studies were excluded for reasons such as qualitative data were presented. Of the remaining 43 studies, 31 were excluded for reasons such as studies measured communications skills, satisfaction and knowledge retention. A total of 12 studies were reviewed [Figure 1].

The reviewed 12 studies evaluated the effectiveness of SBI to improve the psychomotor skills of undergraduate pharmacy students. These studies used the following study designs: six pre- and post-tests; four descriptive with post-test only; one descriptive with repeated measures and one longitudinal research approach. Table 1 presents the design characteristics of the studies.

All studies involved undergraduate pharmacy students. The participating students were mainly from second to final year, and from PharmD programmes (in the US). Of the 12 studies, nine of those were conducted in the US, as well as one each in the United Kingdom, Jordan and Japan. Basheti[16] studied 109 final-year students, Branch[17] studied 127 second-year students, Robinson *et al.*[18] studied 82 second-year students, Tofil *et al.*[19] studied 42 third-year pharmacy students, Tokunaga *et al.*[20] studied 124 second-year students, Seybert *et al.*[4] studied 102 second-year students, Seybert and Barton[22] studied 95 second-year students, Kirwin *et al.*[23] studied 135 third-year students, Frenzel[24] studied 99 final-year students, Zagar and Baggarly[25] studied 18 pharmacy students and Raney[26] studied 250 pharmacy students.

The majority used a combination of active learning strategies. At least three studies reported a combination of didactic lectures followed by simulation-based learning, including high-fidelity training such as demonstration to recognise a medical condition or measurement of vital signs. One study evaluated the effect of counselling real asthma patients on students' demonstration skills of inhalers using simulated scenario.[16] Another longitudinal study, with follow-up at 3 and 6 months, evaluated the effect of simulated, out-of-hospital cardiac arrest management using automated, external defibrillators.[21] Kirwin *et al.*[23] and Frenzel[24] evaluated the use of EMRs in improving patient care skills. See Table 1 for details.

### Study outcomes

The vast majority of competencies and outcome measures were investigated. Outcomes were diverse with differing definitions, methods of data collection, varying time points and different reporting methods. The competencies measured included the correct technique of using inhalers, vital signs measurements, medication review and medication management in patients with low-vision.

#### *Medication-related outcomes*

Nine studies included medication-related competencies as an outcome measure.[4,16-20,23-25] Basheti[16] reported demonstration skill of correct device technique. Tofil *et al.*[19] reported administration of inhaler with spacer and recommended dose of adenosine. Robinson *et al.*[18] reported patient assessment techniques. Seybert *et al.*[4] reported drug management of cardiac dysrhythmia. Tokunaga *et al.*[20] reported identification of the correct route of administration and administration of drugs accurately. Frenzel[24] reported patient-centred care planning. Kirwin *et al.*[23] reported hospital pharmacy skills assessment. Zagar and Baggarly[25] reported identification of medication management difficulties in low-vision patients [Table 1].

#### *Physical examination and medical procedure*

Five studies included physical examination and procedure as an outcome measure.[16,20-22,26] Branch[17] reported recognition of drug-induced dyspepsia. Tokunaga *et al.*[20] reported monitoring of vital signs to identify drug treatment

**Table 1: Simulation-based instruction for pharmacy practice skill development**

| Authors | Country, year | Study design | N | Setting | Simulation-based instruction | Competency measured | Outcome measured |
|---|---|---|---|---|---|---|---|
| Simulation with real patients | | | | | | | |
| 1. Basheti[16] | Jordan, 2014 | Single-blinded, repeated measures, parallel group | 109 | Final-year pharmacy students in the Clinical Pharmacy and Therapeutics course | A simulated scenario counselling real asthma patients | Assessment of correct technique of using inhalers | Improved device technique demonstration skills |
| Human patient simulation | | | | | | | |
| 2. Branch[17] | UK, 2013 | Pre- and post-test | 127 | Second-year PharmD students in the Pharmacology and Therapeutics module | Didactic lecture and high-fidelity human simulation | Demonstration to recognise dyspepsia with ALARM* signs | Improved demonstration to recognise drug-induced dyspepsia |
| 3. Robinson *et al.*[18] | USA, 2011 | Post-test only after simulation activity | 82 | Second-year pharmacy students in Emergencies in the Ambulatory Pharmacy course | Simulated patient + SimMan to display clinical data, in a simulated community pharmacy setting | Application of patient assessment techniques to determine type of emergency, to administer appropriate treatment, to provide appropriate follow-up or referral instructions | Able to apply techniques and identify emergencies |
| 4. Tofil *et al.*[19] | USA, 2010 | Pre- and post-test | 42 | Third-year pharmacy students attending Paediatric Elective, over 2 years | Paediatric human patient simulation in outpatient and inpatient setting | Application of paediatric pharmacy skills | Improved paediatric pharmacy application skills |
| | | | | | | Outpatient: to understand paediatric respiratory distress and to correctly administer inhaler with spacer | |
| | | | | | | Inpatient: to understand supraventricular tachycardia and to prepare and administer the recommended dose of adenosine | |
| 5. Tokunaga *et al.*[20] | Japan, 2010 | Pre- and post-test | 128 | Third-year pharmacy students in the Medical Emergency Care programmes | Monitoring of vital signs, administration of drugs using human patient simulator | Measurement of vital signs and administration drugs accurately | Able to monitor vital signs and administer drugs |
| 6. Kopacek *et al.*[21] | USA, 2010 | Longitudinal study, with follow-up at baseline, 3 and 6 months | 124 | Second-year PharmD students in the CVS Pharmacotherapy course | Didactic lecture and simulated out-of-hospital cardiac arrest case | Application of CPR technique and automated external defibrillator | Able to quickly use automated external defibrillators to deliver a shock |
| 7. Seybert *et al.*[4] | USA, 2008 | Pre- and post-test | 102 | Second-year pharmacy students in the Pharmacotherapy of CVS Disease course | Simulated patient + SimMan software to display heart rhythms | Critical thinking and problem solving in the management of dysrhythmia | Improved ability to resolve patient treatment problems |
| 8. Seybert and Barton[22] | USA, 2007 | Pre- and post-test | 95 | Second-year PharmD students in the Pharmacotherapy | Didactic lectures and a high-fidelity computerised patient simulator | Accurate measurement of BP using human simulator | Improved clinical skills, including accurate BP measurement |

*(Continued)*

**Table 1** (*Continued*)

| Authors | Country, year | Study design | N | Setting | Simulation-based instruction | Competency measured | Outcome measured |
|---|---|---|---|---|---|---|---|
| | | | | of CVS Disease course | | | |
| Use of Electronic Medical Record | | | | | | | |
| 9. Kirwin *et al.*[23] | USA, 2013 | Pre- and post-test | 135 | Third-year PharmD students in the Pharmaceutical Care Skills Laboratory course | Simulated typical hospital pharmacist tasks using an Electronic Medical Record | Simulated typical hospital pharmacist tasks (e.g., medication review, monitoring, medication reconciliation, etc.) | Improved hospital practice skills |
| 10. Frenzel *et al.*[24] | USA, 2010 | Pre- and post-test | 99 | Final-year pharmacy students in the Pharmaceutical Care Skills Laboratory course | Simulated disease state management tasks using an Electronic Medical Record | Development and monitoring of patient-centred care plan. Documentation of recommendations | Improved pharmacy students' patient care skills |
| Simulated/standardised patients or setting | | | | | | | |
| 11. Zagar and Baggarly[25] | USA, 2010 | Post-test only after simulation activity | 18 | Pharmacy students attending Geriatric Elective course | Low-vision simulation goggles in medication management tasks and reflection on experiences | Medication management of low-vision patients | Able to identify the medication management difficulties by low-vision patients and propose solutions |
| 12. Raney[26] | USA, 2007 | Post-test only after simulation activity | 250 | PharmD students attending Disease Management course | Simulated anticoagulation clinic practical examination with a standardised patient | Assessment of vital signs, laboratory values, subjective complaints, clinical recommendations | Reinforcement of skills for delivery of care in pharmacist-managed clinics |

*ALARM = anaemia, unintentional weight loss, anorexia, recent onset of progressive symptoms, melena or upper gastrointestinal bleeding, persistent vomiting and dysphagia.

and adverse events. Kopacek *et al.*[21] reported delivery of shock using automated external defibrillator. Seybert and Barton[22] reported an accurate BP measurement. Raney[26] reported assessment of vital signs reinforcement.

## Study interventions

Because of the heterogeneity of interventions, outcomes and measurements, it was deemed inappropriate to conduct a meta-analysis. The effectiveness of the interventions is described below.

### *Medication-related outcomes*

Basheti[16] found evidence of improvement in demonstrating correct device technique to real asthma patients. Tofil *et al.*[19] tested students' performance in outpatient and inpatient setting and found paediatric patient simulators can improve pharmacy students' knowledge, especially in application of material. Seybert *et al.*[4] examined critical thinking and problem-solving abilities and found improvement in knowledge and ability to resolve patient treatment-related problems. Frenzel[24] investigated students patient-centred care skills and found improvement in pharmacy students' ability to perform patient-centred care. Kirwin *et al.*[23] found evidence of improvement in student confidence and abilities to perform hospital pharmacist duties. Zagar and Baggarly[25] found simulation activity with low-vision goggles effective in identifying medication management difficulties encountered by low-vision patients.

### *Physical examination and medical procedure*

Branch[17] tested the clinical competence of students in identifying the drug-induced dyspepsia and associated symptoms and found significant improvements in students. Tokunaga *et al.*[20] assessed students' ability to monitor vital signs to identify drug treatment and adverse events and found successful preparation of pharmacy students to monitor vital signs to identify treatment-related problems. Kopacek *et al.*[21] found evidence of successful shock delivery using defibrillator by pharmacy students. Seybert and Barton[22] tested students' ability to measure BP accurately and found evidence of significant improvement in students' ability to accurately determine BP following simulation sessions.

## Discussion

The outcomes were medication-related outcomes, physical examination and medical procedure. There was substantial evidence of an effect of the interventions on students' ability to resolve medication-related problems as well as to perform

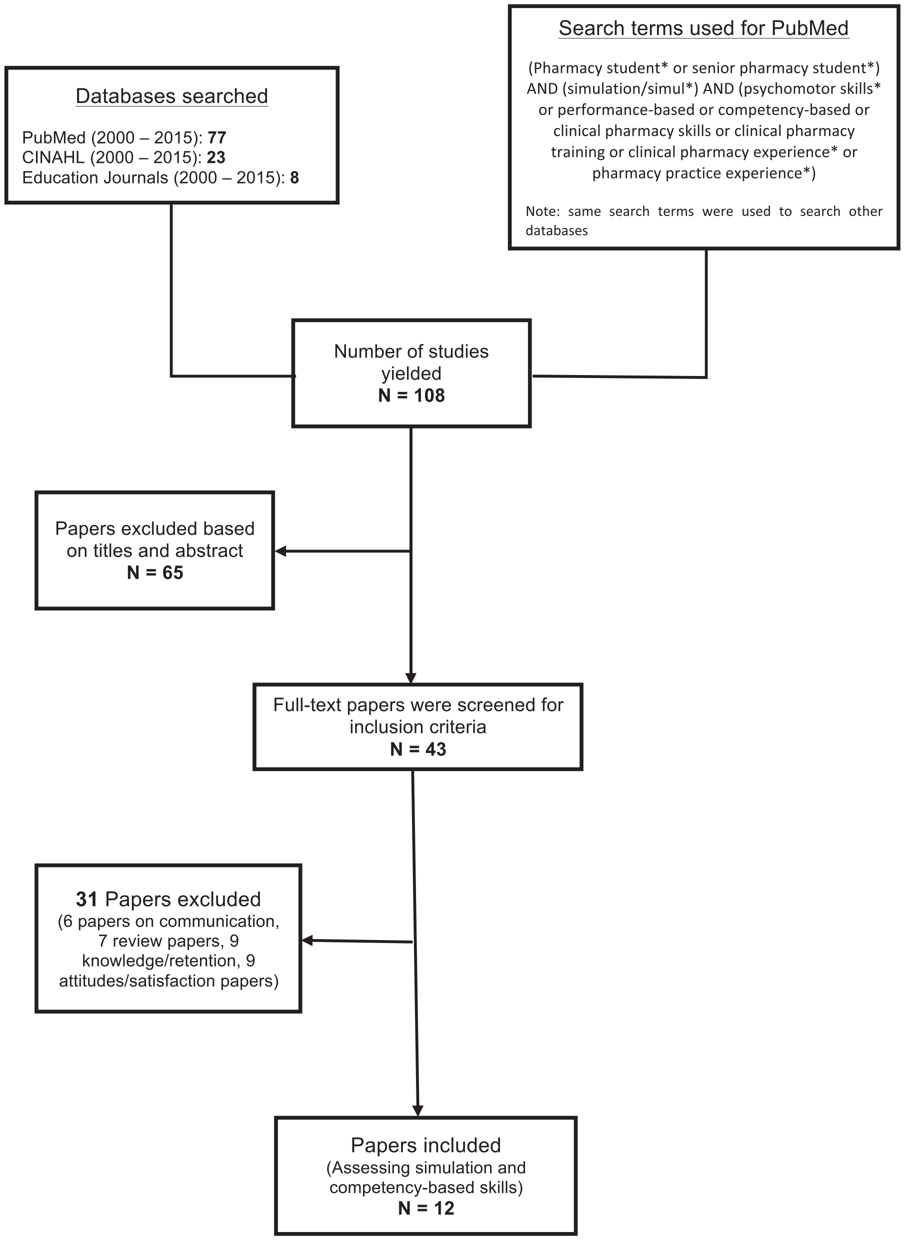


**Figure 1:** Schematic diagram of the literature search

medication review, physical examination and medical procedure. At least two publications have described instructional activities using EMRs. Frenzel[24] described the use of an electronic medical record in a pharmaceutical care laboratory course, where final-year students were assigned to formulate a treatment plan and document their recommendations. The authors concluded that implementation of disease state management activities involving EMRs improved students' ability to perform patient-centred care. Kirwin *et al.*[23] described the process undertaken by faculty members in a Pharmaceutical Care laboratory course to evaluate hospital pharmacy skills using EMR. The paper demonstrated that laboratory simulation can improve skills required in hospital pharmacy practice such as medication review, drug monitoring and medication reconciliation.

Zagar and Baggarly[25] used students to role play patients to help students gain a personal understanding of the medication management difficulties of patients with a variety of impaired vision conditions. The study claimed that this enabled students to devise ways to improve vital access to prescription information and to help minimise the risk of medication errors in this population. Another study designed to review a mock medical record and role-play a follow-up anticoagulation clinic visit using a standardised patient.[26] In one study in pharmacy education, in which specific skills were assessed, students' ability to accurately determine BP significantly improved following completion of practical sessions using a high-fidelity manikin.[22] One study evaluated the effect of an in-class simulation on the assessment and education of real asthma patients in their inhaler use.[16]

All the studies reported positive outcomes of simulation-based education, the major finding being observable improvement in students' clinical skills. Given the complex learning tasks and diversity of simulation-based interventions, identifying educational intervention or component of simulation-based interventions (didactic component or simulated exercise, or the debriefing) that are the most beneficial could be difficult. The multifaceted SBI experiences, including identifying drug-induced dyspepsia, medical emergencies, paediatric pharmacy needs and application of critical thinking and problem solving skills in the management of the dysrhythmia, accurately measuring BP, monitoring of vital signs and drug administration.

Simulation is more commonly used in nursing and medical education than in pharmacy education for learning and practicing clinical skills and procedures.[2,27] However, there is some growing evidence suggesting the use of SBI in pharmacy education to assess psychomotor skills.[5,6] This shift in teaching strategy and use of simulation are narrowing the differences between the role of pharmacists and the roles of more procedure-oriented disciplines such as nursing or medicine. For example, the use of automated external defibrillators and measurement of BP by pharmacy students.[22]

In nursing and medicine, the use of SBI is not restricted to students but is used in higher training. For instance, Barsuk *et al.* used SBI to train internal medicine residents to insert central venous catheters. They reported that the incidence of intensive care unit (ICU) catheter-related blood stream infections was reduced, when residents were trained using simulation, compared to another ICU in the same institution, in which residents were not trained using simulation.[27] Another skills-based study that evaluated medication error rates in a cardiac ICU concluded that simulation-based learning by nurses significantly reduced medication error rates. In contrast, medication error rates did not decrease in the institution's medical intensive care unit where a control group of nurses had completed traditional classroom lecture-based education about medication errors and error rates.[28] These studies are compelling, because they evaluate the use of SBI for education and training of health care professionals in the workplace and evaluate important patient outcomes. This extended role can also present unique research and scholarship opportunities for teaching faculty in clinical setting.

Standardised patients are integral to simulation, which aims to present a consistent medical history and presentation of symptoms to learners.[29] However, there is a new trend of using real patients in a simulated educational environment in the health sciences, and it has yielded positive results.[30] Basheti[16] evaluated the effect of an in-class simulation scenario on the assessment/education of real asthma patients using inhaler devices and found evidence of improvement in students' demonstration skills.

We tried to minimise bias by conducting an extensive literature search and screening studies included published systematic reviews. The review was limited to publications in English. We could not draw robust conclusions because of significant heterogeneity in study design, educational intervention, outcomes and competencies. Only one study was longitudinal;[21] its short follow-up period might have limited the detection of effects on outcomes. Only one study[16] used a single-blinded repeated measure design.

A major limitation of the evidence was the diversity of outcome measures and simulation types, and differences in study method, data collection and analysis. Because there is a lack of valid tools for evaluating simulation, almost all studies reported their findings qualitatively. The overall quality of the evidence for the outcomes reported was judged to be average and therefore, there is uncertainty about the education impact. In summary, the studies reflect a lack of rigour in study design; for example, studies had small sample sizes and/or used post-test-only evaluation. The evaluation tools lacked key components to measure the effectiveness of performance and focussed mainly on satisfaction. In summary our review found great heterogeneity in study design and outcome measures in the small number of studies, which met the eligibility criteria.

The simulation-based interventions discussed improved students' ability to perform psychomotor skills. In addition, evidence from nine studies suggested that the skills could be improved through interventions involving human patient simulation. Despite the improvements in students' ability to perform, there is a lack of evidence on how this translates to real settings and to patient satisfaction. Most simulation-based interventions required significant funding and support, particularly those involving human patient simulation. Like nursing and medicine, a blend of both simulated and real-life clinical experiences should be incorporated into pharmacy education. Rigorous comparative studies are needed to evaluate the effectiveness of different simulation types. Further work is required to develop consensus on identifying, defining, measuring, reporting and analysing important learning outcomes of SBI.

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### Conflicts of interest

There are no conflicts of interest.

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