Pharmacy Education (2024) 24(1) 1 - 12
https://doi.org/10.46542/pe.2024.241.112

RESEARCH ARTICLE

Building capacity for drug development process in Africa–A workable model

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Keywords
Capacity building
Centre of excellence
Drug discovery
Quality medicine

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Abstract

Background: Africa's reliance on drug importation translates to disproportionate transfer of foreign exchange and incessant drug shortages, among other vices. Africans, therefore, need to build capacity in drug discovery, development and production. This article showcases a workable model with an innovative approach of teaching together personnel drawn from Nigeria's academia, pharmaceutical industry and medicine regulation agency. **Method:** Didactic training via postgraduate programmes was designed with hands-on experience in drug synthesis and production. Training and research objectives formed the core of activities. **Result:** The Centre for Drug Discovery, Development and Production (CDDDP), Faculty of Pharmacy, University of Ibadan, was established through grant funding from the MacArthur Foundation. The Centre runs two postgraduate degree programmes, has graduated over forty students, organised four workshops, two international conferences, and translated scientific findings to over eleven finished products. In 2014, the African Medicines Regulatory Harmonisation Programme designated CDDDP a Regional Centre of Regulatory Excellence and since 2019, it has partnered with the United States Pharmacopeia to promote the quality of medicines in low- and middle-income countries (LMIC). **Conclusion:** Capacity building in drug development processes in an LMIC has been developed with resultful outcomes and is proposed as a workable template for other LMICs.

Introduction

Access to essential medicines in Nigeria and Sub-Saharan Africa is presently limited by importation. About 90% of available medicines in Sub-Saharan Africa are imported mainly from Asia, with a few from Europe and the United States of America. Local production is needed to prevent stock-outs of essential medicines (Quick *et al*., 2005; Pheage, 2017; Shukar *et al*., 2021). Inadequate pharmaceutical innovation and sufficiently qualified pharmaceutical scientists within Africa are severely hampering the continent's ability to discover and develop medicines that meet local needs. Existing facilities and academic programmes have not been able to address this problem because there is a shortage of trained personnel required to discover and produce medicines in Sub-Saharan Africa. Similarly, academic institutions are not positioned to fill the gap.

Access to safe and efficacious medicines is not optimal for most people in Sub-Saharan Africa. Consequently, countries spend substantial amounts of foreign currency to import medicines (Berger *et al*., 2010; Adebisi *et al*., 2022). A shortage of qualified professionals has deterred the growth and development of a private pharmaceutical sector capable of providing high-quality, safe, and effective essential medicines in these regions (Ogilvie *et al*.,

2007). Furthermore, Africa suffers from a lack of pre-qualified facilities for drug production and, hence the need for training of personnel for such facilities. The market survey carried out by a team of pharmaceutical experts confirmed the need for specialised training in drug development (Berger *et al*., 2010; Odeku *et al*., 2019; Signé, 2021). A needs assessment conducted among members of the Pharmaceutical Manufacturing Group of Manufacturers Association of Nigeria (PMG-MAN) showed that over 90% of the study population have a keen interest in registering for a graduate programme designed to specialise in drug discovery, development, and production if such exists in their immediate environment. This assessment was done by the authors of this article.

Presently, four pharmaceutical manufacturers out of the over 180 in Nigeria or the Economic Community of West African States (ECOWAS) sub-region have facilities pre-qualified by the World Health Organisation (WHO) for production and quality assurance of essential medicines, although a few others are working hard to be pre-qualified (WHO, 2014; Anyakora *et al*., 2017). In 2011, the WHO reported a 28.5% average failure rate in the quality of antimalarials in sub-Saharan African countries, with Nigeria having the highest incidence rate of 63.9% (World Health Organisation, 2011). These challenges inspired a team of researchers from the Faculty of Pharmacy, allied departments in the University of Ibadan and international collaborators to apply for a MacArthur Foundation grant for higher education to create a Centre of Excellence for Drug Discovery, Development and Production. Higher education is crucial for developing a skilled health workforce and increasing health research capacity. Therefore, it should receive a higher priority in national and regional educational and developmental agendas (Agyepong *et al*., 2017). University systems and the premier university in Nigeria offer an excellent platform for knowledge transfer, capacity building, human capacity development, and marriage of town and gown in evidence-based research, discovery and implementation of systems and structures that facilitate societal developments. This paper therefore describes the conceptualisation and development of a Centre of Drug Discovery, Development and Production (CDDDP) as an adoptable model or template for drug development processes in LMICs.

Methods

In collaboration with international and local partners (Tables Ia-b), the principal investigator met to conceptualise and design a centre that will be focused on capacity building for Africa to make its own drugs in Africa by African scientists. This team's expertise included over thirty years of industrial experience from drug discovery to successful product launch, drug formulation experts, top-notch knowledge in the field of herbal resources for medicines, bioavailability/bioequivalence expertise, chemists with experience in drug synthetic techniques, to mention a few.

Table Ia: List of principal investigators and co-investigators of CDDDP

Name	Designation	Institution
Professor Chinedum Peace Babalola	Principal investigator	Faculty of Pharmacy, University of Ibadan
Professor O.A. Itiola	Co-principal investigator	Faculty of Pharmacy, University of Ibadan
Professor J.O. Moody	Investigator	Faculty of Pharmacy, University of Ibadan
Professor Grace O. Gbotosho	Investigator	Faculty of Pharmacy, University of Ibadan
Dr. M. A. Odeniyi	Investigator	Faculty of Pharmacy, University of Ibadan
Dr. B.B. Samuel	Investigator	Faculty of Pharmacy, University of Ibadan
Dr. O.A. Adetunji	Investigator	Faculty of Pharmacy, University of Ibadan
Mrs. Olayinka Kotila	Investigator	Faculty of Pharmacy, University of Ibadan
Professor Steve Byrn	Co-investigator	University of Purdue, Illinois, USA
Professor Joseph Fortunak	Co-investigator	Howard University, Washington, USA
Pharmacist Kunle Okelola	Co-investigator	Secretary Pharmaceutical Manufacturing Group of Manufacturers Association of Nigeria (PMG-MAN), Lagos, Nigeria
Sister Zita Ekeocha	Co-investigator	Kilimanjaro School of Pharmacy (KSP), Moshi, Tanzania
Professor K. Gammaniel	Co-investigator	Director, National Institute for Pharmaceutical Research & Development, Abuja, Nigeria
Professor Bolanle Adeniyi	Co-investigator	Faculty of Pharmacy, University of Ibadan
Professor S.O. Idowu	Co-investigator	Faculty of Pharmacy, University of Ibadan

Table Ib: Local collaborators/resources persons

Name	Institution
Emeritus Professor A.A. Olaniyi	Department of Pharmaceutical Chemistry, University of Ibadan
Professor O. Oluwatosin	Department of Surgery, Faculty of Clinical Sciences, College of Medicine, University of Ibadan
Professor E. Farombi	Department of Biochemistry, Faculty of Basic Medical Sciences, College of Medicine, University of Ibadan
Professor P.C. Onianwa	Department of Chemistry, Faculty of Science and Head, Multidisciplinary Central Laboratory, University of Ibadan
Dr A. Adedapo	Department of Veterinary Physiology, Biochemistry & Pharmacology, Faculty of Veterinary Medicine and Head of Intellectual Property Rights Office (IPO), University of Ibadan
Dr. Oladosu	Department of Chemistry, Faculty of Science, University of Ibadan
Professor Adeyinka Falusi	Genetics and Ethics of Research, Institute of Advanced Medical Research & Training (IAMRAT) College of Medicine, University of Ibadan
External collaborators/resource persons	
Professor Moji Christianah Adeyeye	Chair Department of Biopharmaceutical Sciences, College of Pharmacy, Roosevelt University, USA.
Dr. Michael Pollastri	Associate Professor of Chemistry and Biology, Northeastern University, USA.
Dr. Christopher Olusola Olopade	Professor of Medicine and Clinical Director, Global Health Initiative (GHI), University of Chicago, USA
Dr Gail Mahady	Associate Professor, University of Illinois, Chicago
Dr. Aomesh Bhatt	Reckitt Benckiser Plc, UK
Dr. Yetunde Kolade	Reckitt Benckiser Plc, UK
Professor Charles Esimone	Dean, Faculty of Pharmacy, Nnamdi Azikiwe University, Awka, Nigeria
Prof. Nelson Ochekpe	Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Jos, Nigeria
Dr. Rebecca Soremekun	Faculty of Pharmacy, University of Lagos, Nigeria

The common goal was to increase the critical mass of pharmaceutical experts from the processes of drug discovery up to production. Specific objectives of the Centre were: 1) to develop curricula and run professional postgraduate diploma and Masters programmes in drug development, industrial and regulatory pharmacy as well as short courses in good pharmaceutical practices (GxP) that will be for target groups; 2) strengthen existing facilities for research and development (R&D) in drug discovery, development, and production; 3) develop pharmaceutical products from the Centre's research findings; and 4) establish a current good manufacturing practices (cGMP) facility pre-qualifiable by WHO for quality assurance of medicines circulating in the sub-region.

The novelty of the project was to provide a platform for seamless interactions between the academia, pharmaceutical industry (Pharma), and drug regulatory agency on drug discovery and development processes (See Figure 1). Funding for the project was to be sought through application to funding calls. Each specific objective had planned activities mapped out in line with the objective and are summarised in Table II.

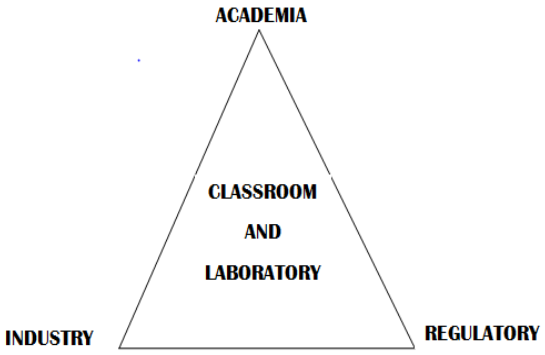

Figure 1: Diagrammatic representation of CDDDP's operational philosophy

Table II: CDDDP objectives and strategic mapping of the projected milestones

Objective	CDDDP strategic activities
To develop curricula and run professional Postgraduate Diploma (PGD) and Masters programmes	Curricula development retreat. Presentation of curricula before Faculty of Pharmacy Postgraduate Committee. Presentation of curricula before Postgraduate School board for approval. Advertisement of the Postgraduate programme to target groups. Admission of students for the Postgraduate programmes Train admitted students using the approved curricula.
Staff capacity development and training	CDDDP staff exchange programme with collaborators/partner institutions Systematic increase in the pool of local faculty trained in drug discovery, development, and production processes.
Workshops and training courses for target groups	Carry out needs assessments in target groups. Conduct hands-on training workshops in areas of observed deficiencies. Hold international conferences involving stakeholders in pharmaceutical strengthening systems.
To develop pharmaceutical products from Centre's research findings	Development of: (i) antifungal cream, (ii) quinine suppositories, (iii) synthesis of Artemisinin
To establish a cGMP facility pre-qualifiable by WHO for quality assurance of medicines	Establishment of a state-of-the-art laboratory for quality assurance of medicines. Engagement of WHO consultants for guidance on pre-qualification process. Training of staff on pre-qualification process. Audit of laboratory facility by May & Baker (a WHO pre-qualified pharma industry).

Results

A proposal was submitted to a call for application by the MacArthur Foundation, and it won a grant of 950,000 dollars (Grant Number 11-97968-000-INP) to set up the Centre for Drug Discovery, Development and Production (CDDDP), University of Ibadan. Quantifiable and qualifiable outcomes in line with the stated objectives of the Centre are herein laid out:

PDDD and MDDRP curriculum development

A two-day retreat was held on 22–23 March 2013, where team members (investigators) drafted curricula for the Postgraduate Diploma in Drug Development (PDDD) and Master in Drug Development and Regulatory Pharmacy (MDDRP) in line with University of Ibadan guidelines.

The PDDD and MDDRP curricula were approved by the Postgraduate School Curriculum Committee in April 2013, ratified by the Faculty of Pharmacy Postgraduate Committee in June 2013, and approved by the Postgraduate School Board in June 2013. The curricula were thereafter approved by the university Senate. Table III captures a few of the topics covered in the two curricula. The two programmes run as 'special postgraduate' programmes. For the PDDD programme, face-to-face contact was for two weeks, twice a year, for a two-year period. This made four modules representing four semesters for the PDDD programme. The Master's programme was designed to be five modules together with series of online interactive sessions with several time-bound assignments, assessments and term paper submissions. The Masters programme runs for two and a half years.

Table III: Selected titles of developed courses in the CDDDP curricula

MDDRP curriculum	PDDD curriculum
Quality management, audits and inspections in the pharmaceutical industry	Fundamentals of drug discovery
Active pharmaceutical ingredients and pharmaceutical solids	Drug development, regulatory and quality compliance
Development and registration of medical devices and diagnostic tests	Drug manufacturing processes
Food and drug laws	Regulatory documents and generic drug approval submissions.
Intellectual property law in drug development	Basics of clinical trials and bioethics in drug development
Good regulatory practices in drug development	Project
Biopharmaceutical and bioequivalence methods for abbreviated new drug application	
Documentation in drug development	
Project	

PDDD and MDDRP graduates

The PDDD programme was advertised, and 17 applicants were admitted in the 2013/2014 academic session. The PDDD was initially structured as a prerequisite for admission into the Master (MDDRP)

programme. Therefore, the Master's programme only commenced after the second PDDD students graduated. The Master in Drug Development and Regulatory Pharmacy began with 18 students in the 2017/2018 session.

The maiden semester/module of the PDDD course was held from 19–30 May 2014. The Centre has since then graduated three sets of PDDD and two sets of MDDRP graduates. Appendices A, B and C are pictures of an instructor, a cross-section of the students and the first set of PDDD graduates. Figure 2 and 3 show the number of graduates, their gender distribution, and their occupational background. Four (4) of the MDDRP students were pioneer students of the Centre, who had previously acquired the PDDD degree. Below are testimonials from some of the students:

> *"My experience of the PDDD program can be summarised in three (3) words: Rigorous, Stimulating and highly expository….. looking forward to the third module, which I expect to be equally educating and stimulating". E.U, Lecturer, Nnamdi Azikwe University, Awka, Nigeria*

> *"This course succinctly addresses the development of requisite skill and manpower to achieve local development and manufacture of drugs for the African continent by Africans. The PGD course affords deeply personalised and interactive tutoring by seasoned and experienced professionals, in addition to tailored sessions which suit the working-class individuals. A combination of these features makes my participation in this course a very worthwhile investment of time and resources (and I definitely recommend the course to anyone with a passion for change in the drug development landscape in Nigeria and the African continent as a whole)". Pharm. YB, Neimeth International Pharmaceuticals Plc.*

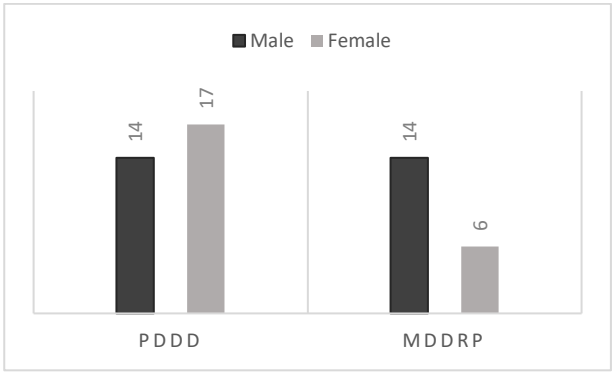

Figure 2: Gender distribution of PDDD and MDDRP graduates

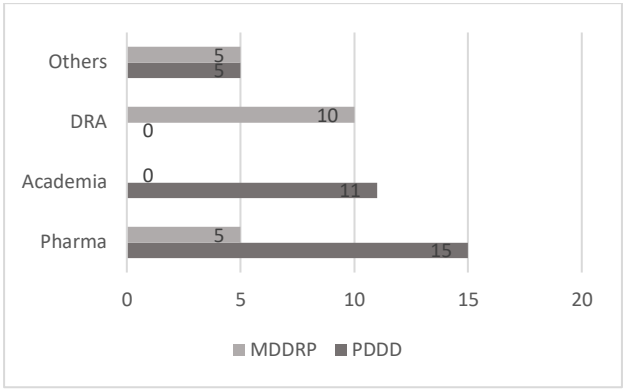

Figure 3: Occupational distribution of PDDD and MDDRP Graduates

Staff capacity development

Staff capacity has been strengthened with valuable training on drug development from various institutions within and outside Africa. All the training programmes have broadened the knowledge base of the local faculty. Some trainings include: i) Industrial Pharmacy Advancement Training programme at Kilimanjaro School of Pharmacy, Moshi, Tanzania; ii) Application of Nanomedicine in Drug Development, Pretoria, South Africa. The knowledge gathered was helpful in the development of a nano-delivery technique for drug delivery of antimalarial-quinine suppositories - which was one of the research projects adopted by CDDDP for development into a finished product; iii) Use of liquid chromatography-mass spectrometry (LC-MS) analytical technique for the assay of drugs in bio-matrices. This was at the African Institute of Biomedical Science & Technology (AiBST) Harare, Zimbabwe; iv) Summer internship in drug discovery in Boston, Massachusetts, USA; v) Training on paediatric formulations of artemether, quinine and artemether-lumefantrine (fixed-dose combination) suppositories with special reference to the tropical environment at the Department of Biopharmaceutical Sciences, College of Pharmacy, Roosevelt University, USA; and (vi) Training on pharmaceutical quality control and good manufacturing practices at the United States Pharmacopeia (USP) sponsored Center for Pharmaceutical Advancement and Training (CEPAT) in Accra, Ghana. This training was specific for the capacity development of laboratory staff employed in the state-of-the-art analytical laboratory in the CDDDP.

Workshops and conferences

The Centre has successfully held four training workshops and two international conferences. In total, CDDDP has trained over 350 professionals in the

pharmaceutical sector through its training programmes. Table IV lists the themes for the workshops and conferences, collaborating partners, and the number of trained participants.

Table IV: Themes for workshops and short-training courses, collaborating partners and number of participants

Year	Theme for the training	Collaborating partners	Number of participants
2013	From Powder to Tablet	BASF, a chemical company	28
2013	International Conference on "Medicine Regulation of Claims"	Reckitt Benckiser, United Kingdom National Agency for Food and Drug Administration and Control (NAFDAC)	150
2015	The Role of Pharmacogenetics in Drug Discovery	African Institute of Biomedical Science and Technology (AiSBT) Harare, Zimbabwe Institute of Advanced Medical Research and Training (IAMRAT), College of Medicine, University of Ibadan, Nigeria	40
2015	Bioinformatics and Computer-Aided Drug Design (CADD)	Nnamdi Azikiwe University, Awka, Nigeria, Afe Babalola University, Ado-Ekiti, Nigeria University of the Sciences in Philadelphia, USA.	28
2016	Molecular and Computational Methods for Emerging Pathogens	UK Medical Research Council /Department for International Development (MRC/DFID) sponsored African Research Leader Molecular Microbiology Laboratory, University of Ibadan	29
2017	International Conference on "Improving Access to Quality Medicines through Appropriate Legislation and Policies".	Africa Medicines Regulatory Harmonization (AMRH) Programme of the African Union (AU)/New Partnership for Africa's Development (NEPAD)	130*

*In attendance were policymakers from the National House of Assembly, Federal Ministry of Health, NAFDAC, health professionals, pharma industrialists, academia and the general public

Translation of research findings to products

One of the objectives of CDDDP was to translate research findings into finished products. Some of the Centre's research outputs include a) Development and formulation of pediatric artemether, quinine, and artemether-lumefantrine (fixed-dose combination) suppositories with special reference to stability in tropical environments; b) Development and formulation of anti-fungi cream from Senna and Ocimum leaves; c) Development and formulation of anti-fungi cream from *Picrilima nitida* bark; d) Synthesis of amodiaquine, as part of the development of artemisinin-based combination therapy using green chemistry technology; e) Development and formulation of teas from edible vegetables that have been documented in the literature to have nutritional benefits such as antioxidants, probiotics, and lipid-lowering potentials (Abarikwu *et al*., 2019; Diez-Echave *et al*., 2020; Njoku *et al*., 2019; Zhang *et al*., 2019). These teas were produced through processes that ensure minimal disruption of their chemical constituents. Dossiers are being developed for them as a prerequisite to their registration by the National Agency for Food and Drug Administration and Control (NAFDAC), which is the major drug regulatory agency in the country; f) In the wake of the ebola epidemic, CDDDP produced alcohol-based hand sanitisers that became adopted by the university for safeguarding the health of the university community. The hand sanitisers were produced in 70 ml handy and 500 ml packs (CDDDP, 2013); g) Activities during Covid-19 were hampered due to the severity of the pandemic. However, post Covid-19, CDDDP as a core-flex partner with the United States Pharmacopeia under the United States Agency for International Development (USAID)-sponsored Promoting Quality of Medicines Plus (PQM+) program, has participated in both online webinar series and face-to-face workshops for personnel of pharmaceutical manufacturing industries across West Africa. Some of the topics taught include: 'Essential Requirements for Developing Quality-Assured, Generic Active Pharmaceutical Ingredients and Finished Dosage Forms', 'Quality Risk Management', and 'Annual Product Quality Review'.

CDDDP's quality assurance laboratory

Recognising the importance of a quality assurance laboratory to teaching and research and ensuring of quality of drugs in circulation, CDDDP established a state-of-the-art laboratory for the quality assurance of medicines. The quality assurance laboratory has anchored over one hundred and fifty graduate research projects from various departments within and outside

the University of Ibadan. It offers third-party analyses to pharmaceutical companies, has undergone auditing in preparedness for WHO pre-qualification, and has established standard operating procedures (SOPs) in line with global standards. WHO consultants have assessed the laboratory and its operations, and a strategic plan for the pre-qualification process has been designed. May and Baker Plc, one of the four pharma industries in Nigeria with WHO pre-qualified facilities, has been to the laboratory for auditing of its equipment and operational processes. The laboratory supports hands-on training for both graduate students of CDDDP and workshop participants. The quality assurance laboratory has served as a source of revenue generation for the Centre. Table III succinctly captures the Centre's stated objectives and achieved milestones.

Awards and recognitions for CDDDP

Products of CDDDP displayed at the 2018 University of Ibadan Research Development (UIRESDEV) fair won First place position. In recognition of the efforts of CDDDP in the sub-region, in May 2014, the African Medicines Regulatory Harmonisation (AMRH) Programme under the New Partnership for African Development (NEPAD) elected CDDDP as a Regional Centre of Regulatory Excellence (RCOREs) in Africa for training in medicine regulation, thus giving the Centre a continental recognition (AUDA-NEPAD, 2022). With this award, the Centre bears oversight functions in training in regulatory science, clinical trials and medicine regulation in Africa. With the current trend and interest in the Centre's programmes and the RCORE designation by NEPAD, CDDDP has become a reference point for training in drug discovery, development, and production processes. In addition to the postgraduate and RCORE programmes, CDDDP is developing need-based short courses for professionals in the medicine production and regulation sector.

Grant application and sustainability plans of CDDDP

The Centre continually seeks collaborations, developing and implementing initiatives that support its mission. The Centre has responded to various local and international calls for proposals. The MacArthur Foundation grant was for five years and ended in 2017. For sustainability, the Centre had attracted an educational grant from Reckitt-Benckiser, United Kingdom (2013), and in the capacity of a sub-recipient, together with the United States Pharmacopeia (USP) won a USAID cooperative agreement for Promoting Quality Medicine Plus (PQM+) in the sub-region (USP, 2019).

Challenges faced

As with the conceptualisation and establishment of any structured setting, CDDDP has also encountered some challenges.

The lack of a pilot facility for manufacturing active pharmaceutical ingredients (APIs), which form a core component of the training module, necessitated travelling the Centre's students to the partner facility in Tanzania for hands-on experience with drug manufacturing. This translated to both travelling and living expenses for the two weeks duration of the programme in Tanzania. The project team succeeded in getting tuition-only sponsorship ($1,500 per student) from UNIDO for the first three sets of PDDD students, but subsequently, students had to make out-of-pocket funding. Grant applications and requests for funding for building a purpose-built facility for pilot manufacturing have been made but to no successful outcome to date.

Operational space for the commencement and daily running of CDDDP was initially carved out of limited office and laboratory spaces within the Faculty of Pharmacy, University of Ibadan. However, with the growing capacity of the Centre and for optimal achievement of the objectives, the Centre needs a purpose-built facility that will handle practical training sessions, drug quality assurance services in accordance with ISO17025 certification, space for bioavailability/bioequivalence (BA/BE) studies and clinical trials, dedicated lecture rooms equipped with multimedia equipment, facility for pilot manufacturing and administrative offices for the staff of the Centre.

It was initially challenging getting the full buy-in of staff/personnel of medicine regulators in Nigeria, namely NAFDAC, Pharmacy Council of Nigeria (PCN), and other nationals, especially in West Africa, to attend the Postgraduate Diploma in Drug Development course. This may be due partly to funding costs associated with the programme and the bias of going for a postgraduate diploma rather than a master's degree programme. This bias initiated the move by the Centre to step down on the acquisition of the PDDD as a pre-requisite for admission to the master's degree programme, which in turn has seen a gradual increase in the number of drug regulators attending the degree course.

Discussion

Good manufacturing practices (GMP) and oversight of medicines exercised by strict regulatory authorities are the basis for assuring the quality of medicines. Despite Nigeria hosting the largest number of pharma industries

on the West African coast, there is still a dearth of these skills and techniques (WHO, 2014). The goal, therefore in CDDDP was to fill in this gap via structured North-South knowledge transfer. Partners from developed countries with robust industrial drug experiences from discovery up to product launch were engaged as key resource persons for designing, developing and teaching the postgraduate curricula. This innovation was to create an enabling environment (i.e. the University of Ibadan), and curricula that would allow for training under the same roof stakeholders within the pharmaceutical strengthening systems. This formed the triangular philosophy of CDDDP (Figure 1). The aim was for these stakeholders in medicine development to be exposed to the same curricula as pertain to drug processes, thereby appreciating the complementary roles they were playing in ensuring the production and circulation of good quality, safe and efficacious drugs. The curricula were aimed to provide professionals working within the pharmaceutical industry, drug regulatory agencies (DRAs), academia, and relevant professions with core knowledge of the scientific, regulatory, clinical, ethical, and social issues relevant to the discovery, development, production, evaluation, registration, and promotion of medicines. The programme targeted capacity building to enhance local manufacturing of medicines and the availability of pre-qualified facilities for drug manufacturing under internationally accepted regulatory guidelines. It was also to improve the quality of health care by developing and promoting skills that hasten the development and supply of new therapeutic agents and to assist in optimising the use of existing medicines and devices to maximise their benefits and minimise risks. An implementation committee was set up that collected data on current medicine development and pharmacy regulatory activities in Nigeria and subsequently assessed the professional development needs of personnel of these sectors (Abate *et al*., 2003; Pheage, 2017; Ekeigwe, 2019). In collaboration with foreign partners, the committee identified the topics to be taught and the areas in which target personnel lacked basic knowledge and practical skills. Also determined was the breadth and depth to which the topics should be taught and the number of hours of instruction per week, to ensure effective learning and transfer of knowledge to the students (International Pharmaceutical Federation (FIP), 2008; Schwartz *et al*., 2013).

The University of Ibadan runs a system of two semesters comprising 13 weeks of lectures. While the constraints of job requirements would not readily permit staff of pharma industries, drug regulatory agencies, and even academia to be given such extended leave of absence from work, the CDDDP team crafted a modified training format that would be suitable to the target students and still be within the confines of the academic system of the university. The goal of the Centre, through the development of the 'special postgraduate' curricula, was to strengthen the skills of people already working in the pharmaceutical industry, drug regulatory agencies and academia in medicine development and regulatory pharmacy (Hammer *et al*., 2010). The dearth of human resource development or capacity building has been identified as one of the main constraints to rapid implementation and success towards strengthening local pharmaceutical production (Kabene *et al*., 2006; WHO, 2012; Babapour *et al*., 2018).

The staff of CDDDP and faculty members of Pharmacy, under the capacity building objective of the Centre, were sponsored to receive valuable and relevant training on drug development from various institutions both within and outside Africa. These trainings strengthened faculty members' skills in various research areas and equipped them with the experience and knowledge required to discharge their duties (Andurkar *et al.*, 2010; Tomei *et al*., 2016). Partnership with the Northern mentoring institutions was an integral part of the implementation strategy of the Centre's services. This was based on the assessment of the kind of strengths needed to support the success of CDDDP.

Organisation of workshops and short-training courses are important aspects of the Centre's activities. CDDDP recognised the impact these trainings have in enhancing the capability and capacity of participants. The workshop style adopted was didactic lectures followed by corresponding hands-on training. This style is not often utilised in the local environment but is highly called for within the nation's circle of healthcare and allied professionals. Workshop organisers often shy away from this style of training because of the high cost involved, the logistics challenges associated with its preparations, especially where laboratory space and consumables are required, and the unwillingness of projected participants to pay workshop fees. Most participants mainly make out-of-pocket payments for such training, which negatively impacts the number of participants who register and attend such training workshops (Idiegbeyan-Ose *et al.*, 2015).

Future plans of CDDDP

With the current trend and interest in the Centre's programmes and the RCORE designation by NEPAD, CDDDP has become a reference point for training in drug discovery development and production. In addition to the postgraduate and RCORE programmes, CDDDP is developing need-based short courses for professionals in the medicine production and regulation sector. Other projects in the pipeline are:

The Centre seeks to set up a bioavailability/ bioequivalence (BA/BE) studies and clinical trials unit to

enhance NAFDAC's regulatory activities by carrying out BA/BE studies of generic drugs circulating in the country – as a prerequisite for registration and as a means of detecting substandard and fake drugs. A proposal for the establishment of the unit has been submitted to the Nigerian Federal Ministry of Health.

Grant applications will be a continuum. The Centre is not relenting in the grant writing efforts. The Centre has responded to various local and international calls for proposals. The Centre has received some grants and submitted proposals to funding organisations such as The European & Developing Countries Clinical Trials Partnership (EDCTP), the Tertiary Education Trust Fund (TETFund), and Management Sciences for Health, Inc (MSH), to mention a few.

Conclusion

A centre for capacity building of Africans in drug discovery, development and production has been established and its model of training together professionals in the academia, pharmaceutical industry and drug regulatory agency is workable and resultful. North-South collaborations are important for continued knowledge transfer, and grant sourcing is a plausible means for funding and sustainability of similar projects.

Conflict of interest

The authors declare no conflict of interest.

Source of funding

The project received grant funding from the MacArthur Higher Education Foundation Grant for Higher Education. Grant #11-97968—000-INP.

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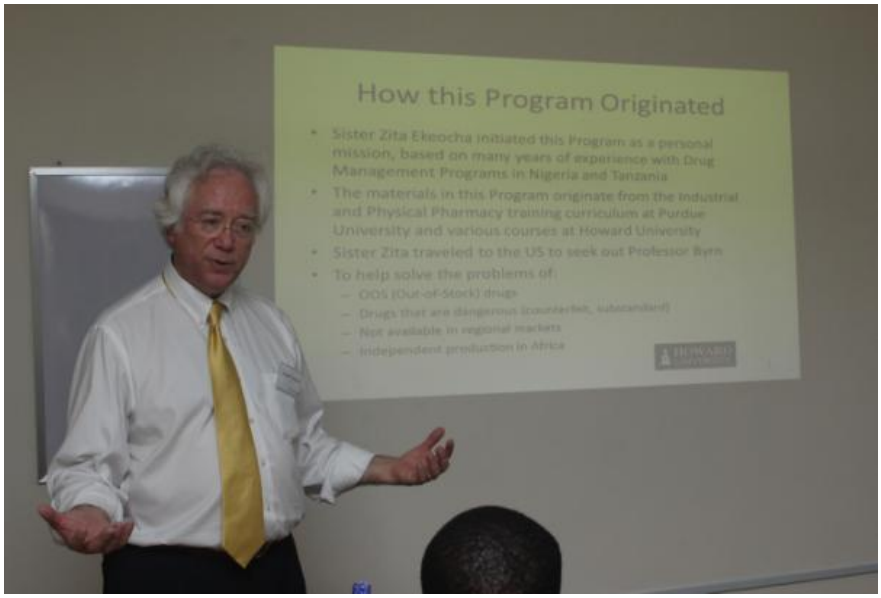
Appendix A: Prof Joseph Fortunak delivering lecture at one of the Postgraduate Diploma training at University of Ibadan in 2014



Appendix B: Cross section of first set (May, 2015) of PDDD students listening with rapt attention

Appendix C: Graduation ceremony for pioneer students of postgraduate diploma in Drug Development (December, 2015)

Pharmacy Education (2024) 24(1) 13 - 21
https://doi.org/10.46542/pe.2024.241.1321

RESEARCH ARTICLE

A call to strengthen medication therapy management training in the Kenyan pharmacy undergraduate curriculum: Feedback from a snapshot of the knowledge and practices among pharmacists in diverse disciplines

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Keywords
Clinical pharmacy
Kenya
Medication therapy management
Patient-centred care
Pharmaceutical care
Pharmacy curriculum

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Abstract

Background: The role of the pharmacist has continued to evolve, placing the profession at the fulcrum of holistic patient care, including offering medication therapy management (MTM), a critical component of any effective pharmaceutical care plan. **Objective:** This study was conducted to assess the knowledge, attitudes, and practices of Kenyan pharmacists regarding MTM. **Methods:** A cross-sectional study was performed whereby Google Form questionnaires were distributed among pharmacists working at hospitals and community pharmacies between 1st October 2022 and 30th November 2022. **Results:** Slightly over half (62, 52.5%) of the pharmacists rated themselves as knowledgeable about MTM, with most participants (55, 46.6%) stating that the undergraduate pharmacy curriculum was insufficient to prepare one to offer MTM services competently. Notably, online courses and workshops were the most popular channels (72%) for accessing MTM-related continuous professional development among the respondents. **Conclusion:** This study revealed some gaps in the knowledge and competence of undergraduate-level Kenyan pharmacists in their quest to offer MTM services. Therefore, embedding MTM in the undergraduate curriculum can bridge this gap and empower Kenyan pharmacists to provide holistic pharmaceutical care.

Introduction

Medication therapy management (MTM) has emerged as a critical specialised service by pharmacists to optimise therapeutic outcomes (Alshehri *et al*., 2022). Delivering effective MTM services relies on implementing five core pillars embedded within the MTM service (Dhatt *et al*., 2023). Medication therapy review (MTR), where pharmacists gather patient-specific data and evaluate therapy for inconsistencies, is the first aspect of MTM. During MTR, an action plan is developed to address any concerns relating to adverse drug reactions. The second step involves compiling a comprehensive list of prescribed and non-prescribed drugs, dietary supplements, and herbal remedies that the patient may be using (Al-Tameemi & Sarriff, 2019). This enables the establishment of a treatment and monitoring strategy using a personal medication record (PMR) and a medication-related action plan (MAP), the third aspect of MTM (Meng *et al*., 2023). Intervention, sometimes in combination with referral, comprises the fourth aspect of MTM. Where necessary, this is implemented, thereby providing the patient with necessary consultation services. The fifth MTM component involves documentation and subsequent patient follow-up involving the attending physician (McBane *et al*., 2015).

There is an urgent need for prudent utilisation and monitoring of medications as part of patients' pharmaceutical care plans. This is revealed by the widespread inappropriate medication use leading to a myriad of avoidable medication-related problems, such as medication errors and adverse drug events or reactions (Ferreri *et al*., 2020). Collectively, an annual loss of over $42 billion is incurred globally in terms of morbidity and mortality due to medication-related matters (Baraki *et al*., 2018). Patient safety is a particularly pressing issue across the African continent. This is due to the region's fragile healthcare infrastructure and scarce resources to support meaningful, holistic patient care in the face of severe health hazards. The problem is further compounded by other competing basic demands, such as food security and access to elementary education (Mekonnen *et al*., 2018).

While the benefits of MTM are obvious, challenges abound in effectively integrating and implementing the service in pharmaceutical care. A lack of recognition of pharmacists' MTM services by prescribing physicians and patients is a frequent obstacle that limits the reach of the service (Rendrayani *et al*., 2023). Additionally, time constraints have limited the extensive implementation of MTM by pharmacists as they grapple with high client traffic. Moreover, inappropriately designed retail pharmacy settings often lack private space for patient consultations (Lasota *et al*., 2015).

Through appropriate intervention, pharmacists can lessen the burden of complex medication schedules. They can also enhance adherence rates and improve the quality of life for patients while reducing the risk of adverse outcomes and the cost of healthcare (Meng *et al*., 2023). Therefore, it is crucial to create and implement collaborative models between physicians and pharmacists. This approach will help to address medication-related challenges in outpatient settings, especially for patients on multiple medications (Hughes *et al*., 2022). By leveraging their knowledge of medications, pharmacists can help their patients achieve better outcomes (Ferreri *et al*., 2020).

Barriers to effective implementation of MTM are especially evident in low- and middle-income countries. A study done in Malaysia, for example, cited lack of training (88.2%), the high cost of implementing MTM service (51.6%) and lack of time (46.2%) as the main barriers to implementation of MTM services. In Jordan, Jarab *et al*. (2022) identified negative physician attitudes (40.4%), lack of training on MTM provision (38.4%), and lack of adequate support staff (37.2%). In a similar study done among Indonesian pharmacists, a lack of interprofessional collaboration, staff, pharmacist knowledge, patient cooperation, documentation systems, stakeholder support, and patient compliance were the most common barriers to MTM implementation (Rendrayani *et al*., 2023). On the African continent, Nigerian pharmacists have reported a lack of staff, time, adequate training and resources as barriers to the implementation of MTM services (Akonoghrere *et al*., 2020).

Locally, the practice and acceptance of MTM in the Kenyan healthcare system are still low, as reflected by the paucity of MTM studies conducted in the country (Aywak *et al*., 2017). Communication hitches, especially when patients are attended to by multiple healthcare practitioners, have been cited as a hindrance to effective patient care (Dorsey *et al*., 2022). This increases the risk of inappropriate medication use, polypharmacy, and medication-related problems. Therefore, increased implementation of MTM services by pharmacists is necessary and holds the potential to deliver coordinated and efficient pharmaceutical care for optimised treatment outcomes.

In Kenya, pharmacists play a crucial role as accessible healthcare providers, particularly in the outpatient setting where they have frequent and extended patient interactions (Aywak *et al*., 2017). They offer various services, including chronic disease management, collaborating with physicians to optimise patient treatment, and addressing care transition challenges (Mulyanga, 2021). Therefore, integrating MTM services into pharmacy practice in the country is essential. This integration would enhance medication adherence and reduce medication duplication and risk for drug-drug interactions. Moreover, it will lower costs and decrease the reliance on additional medical resources such as emergency services and infrastructure (Al-Tameemi & Sarriff, 2019).

Given the gaps in the status and practice of MTM in the country, this research was carried out to assess the knowledge, attitude, and practices of pharmacists in Kenya towards pharmaceutical care, especially regarding the key components of MTM. Improving the expertise of pharmacists and fostering a positive attitude towards it can bring significant benefits towards better patient health outcomes, reduced healthcare costs, and avert preventable morbidities and mortalities.

Method

Study site, population, and design

The study was conducted in Kenya among pharmacists working in the private retail sector (community

pharmacists) and hospital settings (clinical pharmacists). The study entailed a cross-sectional survey of medication therapy management (MTM) services to determine the knowledge, attitude, and practices of pharmacists regarding MTM. Google Form questionnaires were distributed among pharmacists working at hospitals and community pharmacies during the research period between October 2022 and November 2022.

Selection criteria and sample size determination

The study population included all pharmacists working or interning in a community or hospital pharmacy in Kenya. Expatriate pharmacists working in any of the mentioned sectors were excluded from participating in the study. The Fisher's formula size (Charan & Biswas, 2013), was used to calculate the requisite study sample size. Since the total population of pharmacists in Kenya is less than 10,000, the finite size correction formula was incorporated to obtain a sample size of 160. Participation in the survey was voluntary, and participants were required to provide prior informed consent. Refusal to participate in the study did not lead to any prejudice against those who elected to do so. The names of participants and other identifying information were excluded from the data collection.

Sampling technique

A purposive sampling technique was adopted for this study, whereby the principal researcher distributed the study questionnaire to selected pharmacists, who then shared the invitation with other pharmacists in a snowballing approach. The distribution of the study questionnaire was also facilitated by the Pharmaceutical Society of Kenya, the national professional body for pharmacists in the country.

Data collection technique and data analysis

Data was collected using a self-administered structured questionnaire. The structure and questions of the questionnaire were adopted from validated questionnaires used in two prior similar studies (Al-Tameemi & Sarriff, 2019; Akonoghrere *et al*., 2020). The questions and choices were edited and rephrased where necessary for contextualisation. The online questionnaire, designed using Google Forms, contained three main sections. The first section sought to obtain information on the socio-demographic data and knowledge of pharmacists regarding MTM services. The sociodemographic details included age, gender, number of years in pharmacy practice, and education level.

On the other hand, the knowledge-based questions related to knowledge of MTM and sources of information regarding MTM and its similarities to pharmaceutical care. The second section contained questions aimed at obtaining information on the attitudes of pharmacists towards MTM practice. Specifically, the section posed questions regarding the benefits of the five core elements of MTM. The last section sought to find out the MTM practices, if any, among the pharmacists. Questions in this section included whether the pharmacists offer the MTM service, whether they spend enough time counselling patients, and how much the implementation of MTM costs them. A sample questionnaire is attached in the supporting information. Data analysis was performed using Microsoft Excel 2013 and IBM SPSS Version 28. Categorical variables were expressed using frequencies and percentages.

Ethical considerations

Ethical approval to conduct this study was obtained from the Jomo Kenyatta University of Agriculture and Technology Institutional Ethics Review Committee, with the assigned approval number JKU/ISERC/02316/0776.

Results

Sociodemographic characteristics of respondents

Out of the 118 pharmacists who participated in this study, there were slightly more males (63, 53.4%), those aged 24-30 years (61, 51.7%), and those with zero to five years of professional experience (63, 53.4%). Most participants either had an undergraduate degree only (40, 33.9%), an undergraduate degree with additional professional-related certifications (40, 33.9%) or a master's qualification (37, 31.4%). Pharmacists who obtained an undergraduate degree in Kenya (108, 91.5%) formed the largest proportion, as were those who practised in in-patient-public hospitals (49, 30.6%). Based on geographical location, most respondents were from Nairobi and the Rift Valley region (Table I).

Table I: Sociodemographic characteristics of participating pharmacists

Entry	n	%
Gender		
Male	63	53.4
Female	55	46.6
Age (Years)		
24-30	61	51.7
31-40	47	39.8
41-50	7	5.9
51-60	3	2.5
Professional experience (Years of practice)		
0 - 5 years	63	53.4
5 - 10 years	21	17.8
Over 10 years	34	28.8
Level of academic qualification		
Undergraduate	40	33.9
Undergraduate + certifications	40	33.9
Masters	37	31.4
PhD	1	0.8
Undergraduate pharmacy degree		
Kenyan University	108	91.5
University outside Kenya	10	8.5
Pharmacy practice setting†		
Inpatient-public hospital	49	30.6
Inpatient-private hospital	14	8.8
Outpatient-public hospital	36	22.5
Outpatient-private hospital	12	7.5
Community pharmacy	39	24.4
Management level	4	2.5
Private MTM consultancy	1	0.6
Faith-based organisation	1	0.6
Non-governmental organisation	1	0.6
Health technology firm	1	0.6
Academia	2	1.3
Region of practice		
Central	17	14.4
Coast	11	9.3
Eastern	7	5.9
Nairobi	41	34.7
Northeastern	3	2.5
Nyanza	8	6.8
Rift Valley	24	20.3
Western	7	5.9

†: Total tally for this variable exceeds 118 due to the possibility that a pharmacist worked in multiple sectors.

Knowledge about MTM

Sources of information regarding MTM

Professional colleagues (75, 25.0%), online training (69, 23.0%), and live workshops (65, 21.7%) were the most frequent sources of information on MTM for the pharmacists who took part in the study (Figure 1).

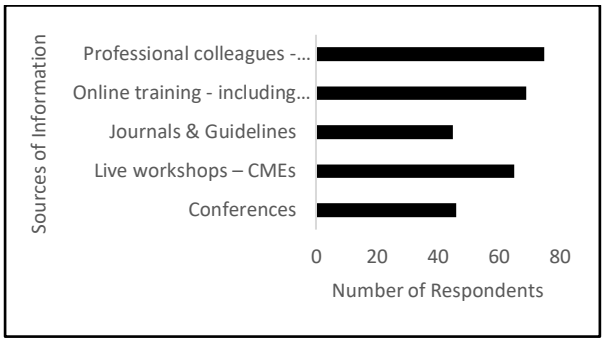

Figure 1: Sources of information on MTM by study participants

Based on their self-evaluation, most pharmacists regarded themselves to be knowledgeable about MTM (62, 52.5%) and pharmaceutical care (82, 69.5%) and agreed that pharmaceutical care and MTM bear similarities (76, 64.4%). However, many (55, 46.6%) disagreed that pharmacy undergraduate training adequately prepares pharmacists to provide MTM services, although they agreed that drug-herb interaction is commonly considered during MTM in local practices (50, 42.4%) (Table II).

Table II: Knowledge of pharmacists regarding MTM services

Statements	n (%)		
	SA + A	Neutral	D + SD
1. I am knowledgeable in MTM	62(52.5)	33(28.0)	23(19.5)
2. I am knowledgeable in pharmaceutical care	82(69.5)	23(19.5)	13(11.0)
3. There are similarities between MTM and pharmaceutical care	76(64.4)	24(20.3)	18(15.3)
4. The pharmacy undergraduate training adequately prepares pharmacists to conduct MTM services.	38(32.2)	25(21.2)	55(46.6)
5. Drug-herb interaction is commonly considered during MTM in local practices	50(42.4)	28(23.7)	40(33.9)

MTM: Medication Therapy Management; SA Strongly Agree; A Agree; D Disagree; SD Strongly Disagree

Notably, most pharmacists who expressed themselves to be knowledgeable in MTM had a higher level of academic qualification, or professional certification, beyond undergraduate training. The years of experience, however, did not affect the level of knowledge of MTM (Table III).

Table III: Knowledge of MTM stratified by level of academic qualification and years of experience

Entry	n (%)		
	SA + A	Neutral	D + SD
Level of academic qualification			
Undergraduate level	16(40.0)	14(35.0)	10(25.0)
Undergraduate + Certifications	25(62.5)	7(17.5)	8(20.0)
Master's and PhD level	21(55.3)	12(31.6)	5(13.2)
Years of experience			
0-5 years	32(50.8)	19(30.2)	12(19.0)
5 – 10 years	10(47.6)	3(14.3)	8(38.1)
More than 10 years	20(58.8)	11(32.4)	3(8.8)

SA: Strongly Agree; A: Agree; D: Disagree; SD: Strongly Disagree

Pharmacists' attitudes towards MTM

Most pharmacists (74.6%) indicated that effective MTM practice required one to know beyond basic pharmacy practice. All MTM core elements, MTR (85.6%), PMR (84.7%), MAP (85.6%), documentation, and follow-up (82.2%), were strongly supported by pharmacists. The same profile was observed regarding the benefits of reviewing a patient's medication profile (89.0%) and intervening in concerning cases (84.7%) in preventing adverse drug reactions. Most study participants (32.2%) also noted that better patient health outcomes can be achieved when a pharmacist monitors a patient's medication compared to other healthcare providers. Furthermore, a similar proportion of pharmacists (32.2%) found providing MTM services to be a unique chance for pharmacists to contribute to holistic patient care (Table IV).

Table IV: Participants' attitude towards MTM

Statements/Questions	n (%)		
	SA + A	Neutral	D + SD
1. **Applying MTM services requires more knowledge than basic information about pharmacy practice**.	88(74.6)	14(11.8)	16(13.6)
2. MTM service is beneficial, considering the five core elements:			
• Medication Therapy Review (MTR)	101(85.6)	7(5.9)	10(8.5)
• Personal Medication Record (PMR)	100(84.7)	5(4.3)	13(11.0)
• Medication-related action plan (MAP)	101(85.6)	7(5.9)	10(8.5)
• Documentation and follow-up	97(82.2)	8(6.8)	13(11.0)
3. To what extent do you agree that the following functions by a pharmacist can prevent adverse drug reactions?			
• Reviewing patient's medication profile.	105(89.0)	4(3.4)	9(7.6)
• Providing interventions to patients whereby the pharmacist acts as a consultant and takes action to resolve any issues with the patient's medications.	100(84.7)	4(3.4)	14(11.9)
4. Compared to other healthcare providers, when a pharmacist monitors a patient's medications, the patient's health outcomes will be enhanced.	101(85.6)	7(5.9)	10(8.5)
5. MTM service provides pharmacists with a unique opportunity to participate in patient care on a broader scale.	104(88.1)	5(4.2)	9(7.6)

MTM: Medication Therapy Management; SA: Strongly Agree; A: Agree; D: Disagree; SD: Strongly Disagree

MTM practices by pharmacists

Table V highlights pharmacists' current practices about MTM and potential impediments to their ability to deploy MTM services in the future. MTM-related online courses (49.2%) and live workshops (72.0%) were identified as effective channels for providing MTM training. Furthermore, most pharmacists (89.8%) were eager to improve their capability to deliver MTM services, and 91.5% attended up to five MTM-related continuing professional development events in the past three months to boost their knowledge and practice. Lack of MTM training (49.2%) was one of the barriers to MTM service implementation. In addition, 59.3% of pharmacies lacked a private counselling area.

Six out of ten (61%) pharmacists stated that they are frequently involved in patient counselling, while another 75.4% believe they will participate in offering MTM services in the future. Most pharmacists agreed that MTM services should be included in community pharmacies (88.1%) and routine pharmaceutical care in hospitals (90.7%). Over half (55.1%) indicated that providing MTM services does not need an expensive budget.

Upon assessment of whether the pharmacists conduct direct patient care, nearly half (47.5%) reported using PMR to communicate and collaborate with other healthcare professionals to achieve optimal patient outcomes. Most study respondents reported using MAP to track their progress towards health goals, with nearly three out of four pharmacists (72.9%) interviewing patients to establish any medication-related problems. Additionally, 61.0% of pharmacists had developed strategies to prevent or correct MRPs, and half of them (50.0%) documented services provided and interventions initiated, including patient follow-up to evaluate progress toward optimum drug therapy goals.

Table V: MTM practices of study participants

Statements/Questions	n (%)		
	SA + A	Neutral	D + SD
1. MTM-related online courses and workshops are an appropriate avenue to provide training for pharmacists.	58(49.2)	26(22.0)	34(28.8)
2. MTM live workshops are preferable in providing training for pharmacists.	85(72.0)	20(16.9)	13(11.0)
3. I participate in continuous professional development training and activities.	74(62.7)	32(27.1)	12(10.2)
4. MTM-related training is one of the potential barriers to applying MTM services in the future.	58(49.2)	26(22.0)	34(28.8)
5. I am interested in learning more information about providing MTM service.	106(89.8)	5(4.3)	7(5.9)
6. I spend a reasonable amount of time counselling patients at my current practice.	72(61.0)	35(29.7)	11(9.3)
7. I believe I will have a reasonable amount of time to offer MTM services in the future.	89(75.4)	21(17.8)	8(6.8)
8. Community pharmacy practitioners should include MTM services as part of their package to advance the impact of the pharmacy profession.	104(88.1)	7(6.0)	7(5.9)
9. MTM services should be incorporated as part of routine pharmaceutical care in the hospital.	107(90.7)	3(2.5)	8(6.8)
10. I was comfortable offering MTM services based on undergraduate qualifications only.	44(37.3)	42(35.6)	32(27.1)
11. Applying MTM services needs an expensive budget	27(22.9)	26(22.0)	65(55.1)
12. I use the Patient Medication Record (PMR) to communicate and collaborate with other healthcare professionals to achieve optimal patient outcomes.	56(47.5)	35(29.6)	27(22.9)
13. I use a Medication-Related Action Plan (MAP) to enable patients to track progress toward health goals	55(46.6)	29(24.6)	34(28.8)
14. I usually ask patients questions to find out if they might be experiencing medication-related problems	86(72.9)	17(14.4)	15(12.7)
15. I design and implement strategies to resolve or prevent medication-related problems	72(61.0)	26(22.1)	20(16.9)
16. I document services and interventions performed in a manner appropriate for evaluating patients' progress	59(50.0)	40(33.9)	19(16.1)
17. I usually follow up with patients to evaluate progress towards drug therapy goals	59(50.0)	35(29.7)	24(20/3)
Questions	**1-5**	**5-10**	**Over 10**
18. How many MTM-related CPD events have you attended in the past three months?	108(91.5)	8(6.8)	2(1.7)
19. In the case that you counsel patients, how much time in minutes do you spend counselling patients?	60(50.8)	40(33.9)	18(15.3)
Questions	**Yes**	**No**	
20. Do you offer MTM service in the facility you are in?	69(58.5)	49(41.5)	
21. Does your pharmacy or workplace currently have a private counselling area?	48(40.7)	70(59.3)	

MTM: Medication Therapy Management; SA: Strongly Agree; A: Agree; D: Disagree; SD: Strongly Disagree

Discussion

Globally, the journey to reaping the benefits of MTM is riddled with contextual challenges. It was due to the scarcity of data on MTM in Kenya, that this study sought to establish the knowledge, attitude, and practices of pharmacists in Kenya regarding MTM. Such data is evidently of inestimable value in characterising the local MTM landscape, identifying the factors affecting current practice and pointing out any existing barriers to effective implementation.

This study revealed that just slightly over half (62, 52.5%) of the pharmacists in Kenya, regardless of the area of specialisation or practice, were knowledgeable in MTM. This is much lower than the proportion of hospital pharmacists in Delta State, Nigeria (94, 94%) (Akonoghrere *et al*., 2020) and Penang, Malaysia (86, 92.5%) (Al-Tameemi & Sarriff, 2019) who declared they know about MTM.

A prior study conducted among community pharmacists in Iowa, USA, found that 90.1% of pharmacists believed MTM services to be an important step in advancing one's pharmacy practice career. A further 86.2% of respondents agreed that using MTM services would provide them with an excellent opportunity to provide better patient care (Jarab *et al.*, 2022). These same attitudes are reflected in the current study, where most pharmacists concurred that pharmacist-led patient medication monitoring would likely result in better patient health outcomes. Also, as observed with a similar study in New York City, USA, most pharmacists favoured the observations of all the five core elements of MTM, finding them to be interrelated and critical in providing improved patient pharmaceutical care outcomes (Shah & Chawla, 2011).

Online courses and live workshops were highlighted as preferred options for transmitting MTM-related knowledge and information. This indicates the vital role that digital technology and platforms play in ensuring continued professional education in the health sector. The flexibility that these modes of interaction provide, coupled with the convenience of accessing the materials later after the course, are important features contributing to their appeal. Moreover, in areas where specialised competencies are still lacking in a certain country or region, engaging a professional colleague or expert based in another country online, as a guest speaker, enables cheaper and more effective knowledge transfer. This option resonates with most of the pharmacists who expressed a great desire to learn more about MTM. Out of these, nearly all had attended at least one course or workshop with professional accreditation, in the last three months.

Designing regular and targeted training on MTM, disseminated via these convenient platforms, can be very beneficial. Specifically, they can be used to address the lack of MTM training which was identified as one of the hurdles to MTM service implementation. Another critical challenge in providing MTM services in pharmacy practice is the absence of a suitable private patient counselling area a resource which approximately 60% of participants in this study agreed to be lacking. In many cases, community pharmacies are small-sized. The bid to maximise space utilisation often ignores incorporating a section where the pharmacist and patient can hold a confidential conversation. It is high time that pharmacists integrated the need for such a crucial space in the design of pharmacies. This will ensure that their premises are adequately aligned to offer holistic pharmaceutical care.

Several other aspects of MTM were applied to varying degrees by study participants. Some 47.5% acknowledged utilising PMR to interact and work with other healthcare providers to achieve optimal patient outcomes. Others used MAP to track their progress toward the attainment of optimum health goals for the patient, an indicator that was less utilised by pharmacists in Nigeria (Akonoghrere *et al*., 2020). Encouragingly, more than half of the pharmacists (72.9%) admitted to asking patients questions to find out if they have medication-related difficulties. A further 61.0% went on to formulate and implement measures to prevent MRPs. However, only half of the pharmacists participated in documentation and patient follow-up to assess progress toward drug therapy goals. This could be a common challenge across the profession. Work-related strains and poor administrative support to enable pharmacists to focus on professional service delivery can be partly remedied by office support in archiving and recording patient data for follow-up.

For the first time, this study highlights the knowledge, attitudes, and practices towards MTM among Kenyan pharmacists practising across disciplines and in different settings. The cross-sectional design of the study was intended to provide a snapshot of the situational analysis. Against this backdrop, further extensive follow-on research can be based to pursue a comprehensive understanding of factors and circumstances facilitating or hindering the uptake and execution of MTM. It was encouraging to observe that most pharmacists have a positive outlook towards offering MTM services. Moreover many were already applying MTM knowledge in their practice to varying degrees, albeit with notable challenges, including time and space constraints.

The clinical implications of these findings are noteworthy. This will be evident when it is borne in mind that the utility of MTM in ensuring optimal pharmaceutical care outcomes is a proven and acknowledged fact. Most of the respondents in this study showed a positive attitude towards offering MTM services. This serves as an impetus for the promotion of MTM services by removing identified barriers to implementation, the key of which is the lack of adequate training on MTM. The result will be the effective use of medicines to achieve treatment outcomes, increased quality of patient care and cost-effective use of medicines.

Limitations

This study was however limited by its cross-sectional design, which confines the findings to the study period. Moreover, potential biases in self-reported data may be present accruing from the fact that data was collected via a self-administered questionnaire. Notably, the purposive sampling technique used in data collection in combination with snowballing limits the generalisability of the findings. Future research aimed at establishing interventions that would be effective in overcoming identified barriers to MTM implementation is recommended. Consequently, the review of pharmacy undergraduate curriculums in Kenya should include MTM training.

Conclusion

In conclusion, this study revealed gaps in the practice of MTM by Kenyan pharmacists, which, if addressed, can extend the frontiers of effective pharmaceutical care. Many participants noted that MTM practice requires more than a basic understanding of pharmacy practice, which is a motivation for the embedding of MTM practice in the undergraduate curriculum and subsequent internship phase before deployment into pharmacy practice. The willingness of the pharmacists surveyed in this study to receive further MTM training and participate in future related research is an encouraging sign that should be harnessed towards MTM implementation across community and hospital pharmacies for optimal patient pharmaceutical care.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgement

The authors hereby acknowledge the assistance of the Pharmaceutical Society of Kenya in distributing the study questionnaire, enabling us to collect vital data for this research, and Veronica Amoit Wechuli for the useful discussions towards the development of this manuscript.

Source of funding

The authors did not receive any funding.

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Pharmacy Education (2024) 24(1) 22 - 28
https://doi.org/10.46542/pe.2024.241.2228

RESEARCH ARTICLE

Impact of curricular and institutional factors on Pharm.D. students' NAPLEX success: A comprehensive analysis of US pharmacy programmes

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Keywords
Curriculum
Doctor of Pharmacy
NAPLEX
Pharmacy
Pharmacy education

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Abstract

Background: Curricula and institutional factors in pharmacy schools play a pivotal role in shaping students' readiness for the North American Pharmacist Licensure Examination (NAPLEX). The factors that influence student success remain uncertain. This research explores the association between various aspects of pharmacy school curricula and NAPLEX pass rates. **Methods:** Data on various aspects of pharmacy programs across the United States were collected, including curricular structure and content. Multiple linear regression analysis was conducted to investigate the correlation of factors with NAPLEX pass rates. **Results:** The four-year programmes and research-focused institutions, with a curricular emphasis on practice management, pharmacology, pharmacotherapy, and APPE, had a positive relationship with NAPLEX pass rates. Focus on Pharmaceutical Calculations had a negative relationship with NAPLEX performance. All other factors were non-significant. **Conclusion:** This study provides valuable insights into the determinants of NAPLEX pass rates. It underscores the importance of a well-rounded curriculum and a balanced course selection to enhance student performance.

Introduction

The field of pharmacy education is dynamic and constantly evolving to adapt to the changing demands of the healthcare environment. The curriculum and course content offered by pharmacy schools in the United States (US) and worldwide play a crucial role in shaping the competence and preparedness of aspiring future pharmacists. The variations in curricula can significantly influence how pharmacy students perform on licensure exams like the North American Pharmacist Licensure Examination (NAPLEX). While pharmacy schools aim to improve their graduates' NAPLEX pass rates, it is indeed a challenging task. Despite these efforts, reliable indicators of NAPLEX success have not been definitively identified at this point (Park *et al.,* 2021).

First-attempt NAPLEX pass rates have recently become a primary source of concern for colleges and schools of pharmacy, with national pass rates beginning to drop in 2014, with the most substantial drop occurring between 2015 and 2016 (Williams, 2017; Williams *et al.,* 2019). Following the decline in national pass rates, there has been much interest in identifying student exam achievement characteristics (Fiano *et al.,* 2022). Educators and institutions need to understand and comprehend the relationship between curriculum types, course contents, and the number of credit hours in each discipline and how they impact NAPLEX first-time pass rates.

Many schools consider the NAPLEX preparation programme essential to preparing students for success. However, little or no association exists between first-time NAPLEX pass rates and NAPLEX preparation programme characteristics (Fiano *et al.,* 2022; Sobieraj *et al.,* 2023). Researchers showed some correlation of NAPLEX pass rates with specific programme characteristics, such as the presence of academic health centres, multiple campuses, accreditation time of schools, programme structure and type, and student-to-faculty ratio. It has been recommended that individual programmes proactively and critically evaluate their educational programmes and the readiness of their students for the NAPLEX (Williams *et al.,* 2019; Ried *et al.,* 2022). The programmes' class size and public/private status have also been shown to influence student success (Jimenez et al., 2019). Multiple course remediations have been found to negatively impact NAPLEX pass rates (Kane *et al.,* 2023), underscoring the significance of curriculum, content, and educational resources in addressing overall student success, including NAPLEX competencies.

Pharmacy schools may adopt varying curriculum models, including traditional didactic coursework emphasising fundamental science and pharmaceutical knowledge, team-based learning, and an integrated approach incorporating more hands-on or clinical experiences early in the programme. Pharmacy education differs significantly between institutions and geographical areas. These differences are reflected in course content, curriculum types, and credit hour distribution among different subject areas (Gleason *et al.,* 2013; Talasaz *et al.,* 2023). Understanding the strengths and weaknesses of varying curriculum types and contents is essential to assessing their impact on students' NAPLEX performance. It is also vital to ensure that the curriculum includes the necessary knowledge and skills required for pharmacy practice, aligning with the evolving healthcare landscape. The allocation of credit hours to different subjects or courses can influence the depth of knowledge. A balanced distribution of credit hours is essential to ensuring that students are adequately prepared for all aspects of the profession.

The assessment methods used within the curriculum can also affect how well students retain and apply their knowledge (Mort & Messerschmidt, 2001; Peterson *et al.,* 2011; Hein *et al.,* 2019). Frequent assessments, including practical exams and clinical rotations, can contribute to better preparation for licensure examinations, including the NAPLEX. Pharmacy schools should provide dedicated resources and support, including review courses, practice exams, and guidance on effective study strategies, to help students prepare for licensure exams. Collecting and analysing data on NAPLEX scores and the performance of students from different programmes can help identify strengths and weaknesses in specific curricular elements and make data-driven improvements.

This study aims to investigate the relationships between curriculum types, course content, credit hour allocation, and first-time NAPLEX pass rates. It also aims to provide data-driven insights that can guide curricular decisions and improve the educational experiences of pharmacy students by carefully examining these variables. The overarching goal is to encourage further advancements in pharmacy education and the training of knowledgeable, competent pharmacists who meet the needs of future healthcare practice.

Methods

Design

As of July 2023, the information on the accredited US pharmacy programmes was collected from online public sources. NAPLEX pass rates were obtained from the National Board of Pharmacy (NABP) and ClinCalc websites (Clincalc, 2023; NABP, 2023). During the summer of 2023, the above sources were searched to collect the following publicly available data for each US school or college of pharmacy: curricular structure; content and credit hours; programme structure (traditional four-year curriculum *vs* accelerated three-year curriculum); programme type (public *vs* private); research status (research-intensive *vs* teaching-focused); student diversity index for Autumn 2014-2018 enrolment classes; State and region of the school; and NAPLEX first-time pass rates for 2018-2022. The number of credits for all courses was obtained from each school's website, and each school's total number of credits was computed. The diversity index (DI) was calculated from the Student Enrolments data with ethnic breakdowns publicly available for AACP members on their institutional research site. The calculation was conducted by using the following formula [Simpson, 1949]:

$$DI = 1 - D; \quad D = \frac{\sum_1^7 n(n-1)}{N(N-1)}$$

In this equation, D = Simpson's Diversity Index; N = number of individuals in the total student population in all racial/ethnic groups; n = number of individuals in each racial group.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics 2023. Categorical variables were summarised

using frequencies and percentages, while continuous variables were summarised using means and standard deviations.

All categorical variables (region, state, programme duration, integrated curriculum, research or teaching, and public or private) and all continuous variables, including the number of credit hours in each area and each course, the total number of credit hours in each programme, and the diversity index, were included in the multiple linear regression analysis. Schools with research-based Ph.D. and/or MS programmes were research-focused, while schools with professional Pharm.D. degrees without research-based graduate programmes were teaching-focused. Only relevant or significant variables were reported in the result tables.

Results

The Accreditation Council for Pharmacy Education (ACPE) Standards 2016 Appendix 1 included a total of 37 subject areas in four core areas (not shown in the table): biomedical sciences, pharmaceutical sciences, social, administrative, and behavioural sciences, and clinical sciences (Accreditation Council for Pharmacy Education, 2015). Among all 135 schools evaluated, over 90% dedicated one or more credits to nine out of 37 content areas, i.e. medicinal chemistry, pharmaceutics, pharmacology, biopharmaceutics, pharmacy law, professional communication, health information retrieval and evaluation, patient assessment, pharmacotherapy, and electives.

The content area with the highest average term credit hours (SCHs) allocated was pharmacotherapy, with an average of 27.7 SCHs, followed by pharmacology, with an average of 8.9 SCHs. All these subject areas and their credit hours were analysed to determine any correlation with the NAPLEX pass rate.

Table I contains a detailed breakdown of categorical variables relevant to pharmacy programmes, such as programme duration, integrated curriculum, regional location, research or teaching focus, and public or private status. It also displays the average NAPLEX first-time pass rates for these categories, giving a comprehensive picture of the characteristics and outcomes of the programmes under consideration. Integrated curricula were available in a slightly higher percentage of programmes, with 63% adopting this approach. The region with the highest NAPLEX average (91.29%) was the "*Great Plains*," while the lowest NAPLEX average was found in "*New England*" (81.10%). The distribution between programmes focusing on research (50.4%) and those emphasising teaching (49.6%) was relatively balanced. Additionally, there were slightly more private (51.9%) than public (48.1%) programmes. The majority of schools (57.8%) performed better than the national average on NAPLEX.

Table I: Frequencies and percentages of the important categorical variables

Variable	Category	Frequency	Percentage	NAPLEX average
Programme duration	3 Years	17	12.6	79.39
	4 Years	118	87.4	85.57
Integrated curriculum	No	49	36.3	85.30
	Yes	85	63.0	84.49
Region	New England	16	11.9	81.10
	Mid-Atlantic	19	14.1	83.62
	South	27	20.0	84.92
	Midwest	22	16.3	85.50
	Great Plains	8	5.9	91.29
	Rocky Mountains	17	12.6	85.75
	Southwest	7	5.2	86.35
	West Coast	19	14.1	83.94
Research or teaching	Teaching	67	49.6	81.30
	Research	68	50.4	88.26
Public or private	Private	70	51.9	82.00
	Public	65	48.1	87.82
NAPLEX first-time pass rate (%)	<National average	57	42.2	77.46
	> National average	78	57.8	90.20

Table II summarises the average credit hours for each core subject area. It includes multiple linear regression analysis results for selected subject areas, other significant variables, and the corresponding *p*-values at 95% confidence intervals (CI). The average NAPLEX first-time pass rates for 2018–2022 ranged from 59.1 to 97.3, with a mean of 84.81±7.90. Schools with a strong emphasis on courses such as pharmacology, pharmacotherapy, practice management, and APPE had a positive effect.

In contrast, schools with a strong emphasis on pharmaceutical calculations appeared to have a negative impact on NAPLEX performance. No significant correlation was observed with other specific or core subject areas. Moreover, the total SCHs required to complete the degree programme, spanning from 124 to 169, did not significantly influence NAPLEX scores.

As per Table II, pharmacy programme duration was a significant predictor of NAPLEX scores. Students in 4-year programmes tended to perform better on the NAPLEX than those in 3-year programmes. Also, research-focused institutions substantially influence NAPLEX scores with better performance. Integrated *vs* non-integrated curriculum was not significantly associated with NAPLEX score outcomes.

Table II: Average credit hours for core subject areas of Appendix 1 of ACPE Standards 2016, multiple linear regression analysis of selected variables in Doctor of Pharmacy curricula (N=135)

Core subject area	Min credit	Max credit	Mean ± (SD)	B	*P*-value (95% CI)
Pharmaceutical calculations	0.00	8.00	1.66 (1.35)	-1.483	.026 (-2.785&-.181)
Practice management	0.00	12	2.72(1.78)	1.397	.004(.469&2.325)
Pharmacology	0.00	20.0	8.86(3.35)	.714	.005(.219&1.208)
Pharmacotherapy	13	55.00	27.73(7.62)	.396	.003(.138&.655)
APPE	24	66.00	38.38(4.96)	.411	.005(.129&.693)
Electives	0.00	17.3	6.85 (3.15)	.460	.098 (-.087& 1.006)
Grand total credits	123.7	169.0	145.9 (8.62)	.058	.689(-227&348)
Diversity index	10.26	76.75	53.96 (13.87)	-.074	.205 (-.190&.041)
NAPLEX first-time pass rate	59.1	97.3	84.81 (7.90)	NA	NA
4-year programme	NA	NA	NA	8.022	.002(3.057&12.987)
Fully integrated	NA	NA	NA	-1.703	.342(-5.250&1.843)
Public or private	NA	NA	NA	-.306	.893(4.830&4.218)
Research or teaching	NA	NA	NA	6.910	.003(2.487&11.333)

ACPE=Accreditation Council for Pharmacy Education; No credit may mean the courses are integrated within other areas or are taught as part of pre-pharmacy course requirements.

Discussion

This study investigated the relationship between curricular variables, institutional characteristics, and first-time NAPLEX pass rates in pharmacy schools and colleges nationwide.

Maintaining a current curriculum that equips students for entry into pharmacy practice is an ongoing issue for all Pharm.D. programmes recognised by ACPE (Lloyd, 2020). Programmes need to re-evaluate how much time should be spent on a given subject in light of changing practice roles every time curricula are updated (Talasaz *et al.,* 2023). They must decide which material to cut each time new information is added to the curriculum to keep students from becoming overwhelmed and avoid curricular hoarding (Romanelli, 2020). Several schools have taken measures to incorporate competency-based education and integrated courses as the field has developed toward a more complicated practice role for pharmacists (Talasaz *et al.,* 2023).

The findings of this study show the average credit hours allotted to core subject areas, elective courses, and experiential education in Doctor of Pharmacy programmes and the related average first-time NAPLEX pass rates. While biomedical, pharmaceutical, social and administrative, and clinical sciences, which require various credit hours, reflect the range of educational designs, the allocation of a significant number of credit hours for experiential education emphasises the critical importance of the latter in pharmacy education.

The average NAPLEX pass rate across all universities was a solid 84.81%. It is essential to highlight the differences between institutions in programme

duration, integrated curriculum, geographic region, concentration on research or teaching, and public or private status. One notable finding is the disparity in NAPLEX pass rates across colleges offering 3-year and 4-year programmes. Students enrolled in 4-year programmes had a higher average NAPLEX pass rate (85.57%) than those in 3-year programmes (79.39%). The multiple linear regression analysis of programme duration and NAPLEX scores showed statistically significant results ($p < 0.05$), indicating an association between the two variables, consistent with previous findings (Williams *et al.,* 2019). However, the analysis of fully integrated curricula and public *vs* private schools did not yield statistically significant results, in contrast with the conclusions of other studies (Jimenez *et al.,* 2019; Williams *et al.,* 2019).

The analysis of research *vs* teaching-focused institutions yielded highly significant results, with students in research-focused institutions performing significantly better in NAPLEX. Although research activities may not directly educate Pharm.D. students or align with the NAPLEX blueprint, the positive correlation may highlight enhanced institutional resources, faculty expertise, and elective opportunities. These factors can collectively contribute to improved educational experiences across various areas, potentially leading to better overall performance.

Only pharmaceutical calculations, pharmacology, pharmacotherapy, practice management, and APPE were significant in the regression analysis that examined the means of NAPLEX scores and all pharmacy courses and domains. For instance, schools that allocated more credits to pharmaceutical calculations tended to perform lower on NAPLEX, suggesting their oversight of the importance of other topics. The emphasis on calculations without in-depth study of other areas may contribute to students' lower performance at NAPLEX. Electives offer students flexibility to tailor their education according to their interests, career goals, and specialisations, which might help students choose the courses they need to fill the gap in knowledge in these areas; however, it was not significant.

Multiple subject areas substantially influence NAPLEX performance, suggesting that it is not a single subject that is crucial for student success but a balanced course offering. Overall, this study could provide valuable insights into the factors influencing NAPLEX pass rates in pharmacy schools and colleges across the US.

Some of the main findings and implications from the study are:

1. Curriculum design and credit hours. This study highlighted the variability in the number of credit hours allocated to core subject areas such as biomedical, pharmaceutical, social administrative, clinical sciences, and experiential education. It also underscored the importance of experiential education in pharmacy programmes.

2. Programme duration. This study revealed a significant difference in NAPLEX pass rates between 3-year and 4-year pharmacy programmes, with the latter having higher pass rates, suggesting that more extended, comprehensive programmes may better prepare students for the NAPLEX.

3. Integrated curriculum. This study indicates that the level of integration within the curriculum does not significantly affect NAPLEX scores, suggesting that the curriculum format (integrated or not) does not necessarily correlate with student performance.

4. Public vs private institutions. This study could not find differences in NAPLEX pass rates between public and private institutions.

5. Research focus. This study found a positive association between institutions prioritising research activities and higher NAPLEX pass rates, suggesting the potential benefit of improved institutional resources, faculty expertise, elective opportunities, and educational experiences in multiple areas in contributing to better performance.

6. Course specifics. Some courses like pharmaceutical calculations, pharmacology, pharmacotherapy, practice management, and APPE were significantly associated with variations in NAPLEX scores. While other subject areas were positively correlated with NAPLEX performance, pharmaceutical calculations content was negatively associated with NAPLEX performance, indicating that a more balanced curriculum might be beneficial.

Future directions

While these findings provide valuable insights, they represent correlations rather than causations. Further research would be necessary to establish causal relationships and better understand the underlying factors influencing NAPLEX pass rates.

However, these findings can serve as a starting point for institutions to consider improving NAPLEX pass rates, potentially by adjusting their curriculum, programme duration, or other factors to better prepare students for this critical examination. They also offer a roadmap for enhancing the quality of pharmacy education and ensuring that future pharmacists are well-prepared for their roles in the healthcare industry. Collaborative efforts between schools and colleges of pharmacy may help refine these findings and continue improving the quality of pharmacy education.

Limitations

This research has a few limitations. First, it did not include all schools, as not all provide their complete curriculum on their website. Nonetheless, the participating schools were evenly split between private (51.9%) and public (48.1%) schools, mirroring the national distribution (52% private, 48% public) (AACP, 2023). Second, the data collection relied on publicly accessible websites, assuming that each school's webpage is regularly updated, which may not be the case for all schools. Third, publicly available data and course descriptions were used to determine credit allocations for each content area. Integrated courses covering various subject areas were assessed by the authors and were not validated by contacting school-specific personnel.

Conclusion

This comprehensive study offers a valuable understanding of the multiple factors associated with NAPLEX pass rates in Pharm.D. programmes, including programme duration, research or teaching focus, and specific courses. These findings are valuable for pharmacy schools and institutions as they consider curriculum design, programme duration, research integration, and the importance of particular courses to improve student preparedness for the NAPLEX. However, it is imperative to reiterate that these findings represent correlations, and further research is needed to determine causal relationships and explore other potential factors that can influence NAPLEX performance.

Ethics approval and informed consent

Exempt #23-033 University of Charleston IRB.

Conflict of interest

The authors declare no conflict of interest.

Source of funding

The authors did not receive any funding.

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Pharmacy Education (2024) 24(1) 29 - 39
https://doi.org/10.46542/pe.2024.241.2939

RESEARCH ARTICLE

Students' performance and perceptions of mock trials as a teaching and assessment activity over three years at two institutions

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Keywords
Debate
Inter-institutional collaboration
Mock-trial

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Abstract

Background: This study aimed to evaluate students' performance and perception of a mock-trial teaching, learning, and assessment activity over three years at two institutions. **Methods:** A mock trial (courtroom-style debate) implemented over three years (2017-2019) in a first professional year (P1) course at two institutions offered active learning in literature critique and evaluation, critical thinking, communication, teamwork, professionalism, and self-awareness. Student teams researched, prepared, and debated controversial topics as counsels, witnesses, or jurors for alternate mock trials. Descriptive analyses evaluated judge and juror trial scores and the 2019 Technology Acceptance Model (TAM) survey. **Results:** The mock trials involved 319 student participants (Programme A: 136; Programme B: 183). Faculty-judge scores ranged from 83.3% to 97%, while student-juror scores ranged from 87.5% to 100%. Most student groups in all programmes reported comparable faculty-judge scores and student-juror scores, irrespective of trial positions (pro or con) or topics. The TAM survey assessed 96 student participants' perceptions of Blackboard Collaborate for peer collaboration in 2019. Items assessing students' attitudes toward mock trials reported an average rating above 5 on a 7-point Likert scale. **Conclusion:** A three-year retrospective evaluation of students' performance and perceptions of mock trials at two institutions demonstrated the effectiveness of mock-trial innovation and the feasibility of cross-institutional student engagement and faculty collaboration.

Introduction

The mock-trial project (courtroom-style debate) aimed to develop student's skills in affective domain competencies, including collaboration, communication (written and verbal), professionalism, and advocacy, which skills were identified as essential for health professions graduates by the Interprofessional Education Collaborative (IPEC) expert panel (Interprofessional Education Collaborative, 2016). Those affective domain skills were subsequently embraced by the Centre for the Advancement of Pharmacy Education 2013 Educational Outcomes ("*CAPE 2013 Outcomes*") (Medina *et al.,* 2013) and soon after adopted by the Accreditation Council for Pharmacy Education (ACPE) in the Accreditation Standards 2016 (Accreditation Council for Pharmacy Education, 2015). In the backdrop of those pivotal developments, pharmacy educators also recognised the need to address dynamic changes in the profession because the long-sought expansion in the scope of pharmacy practice would place pharmacists in both direct patient contact and care with expanded roles and responsibilities. The skills deriving from the affective domain, historically dismissed by pharmacy educators focusing solely on the cognitive domain, now become vital to the pharmacy profession (Medina *et al.*, 2013; Accreditation Council for Pharmacy Education, 2015; Interprofessional Education Collaborative, 2016).

These overarching developments commanded deliberate and focused efforts across pharmacy education to cultivate, develop, and reinforce affective domain skills in student pharmacists.

These developments in pharmacy education inspired the original adaptation of a mock trial to a self-directed, team-based project within an evidence-based practice course in 2015 (Rosenberg *et al.,* 2018). A literature review at the time documented mock trials as a common active learning strategy in graduate study, particularly in law schools, as well as a broad variety of other educational contexts (economics, education, management, communication, public speaking, critical thinking, and ethical decision-making) (Rosenberg *et al.,* 2018). However, limited use of mock trials was identified in pharmacy education.

Therefore, designing the mock trial activity in pharmacy education was started from scratch in 2015. In addition to the requisite cognitive and knowledge-based skills and activities gained in the course (research, evaluation, and critique of evidence), the mock-trial design deliberately aimed for activities in the affective domains (e.g. professional attitudes, advocacy, communication skills, etc.) that were critical to the practice environment and were highlighted as desired competencies by the IPEC panel (Interprofessional Education Collaborative, 2016), and newly required for the Pharm.D. curriculum by CAPE (Medina *et al.,* 2013) and ACPE (Accreditation Council for Pharmacy Education, 2015). The mock trial activities in the Pharm.D. curriculum served as a mechanism to introduce student pharmacists to working collaboratively in teams toward shared goals such as searching the literature and identifying and advancing their team's best evidence-based arguments at trial. The mock trial project took place in the second term of the first professional year (P1), which enabled students' active learning in the cognitive and affective domains well before their exposure to interprofessional teams in an experiential setting. Since the project was self-directed throughout the term, students were practising skills in communication (written and verbal), collaboration, and advocacy. Requiring research, identification, and ranking of evidence according to the evidence pyramid and its hierarchy engaged students in the application of knowledge and skills necessary to retrieve and critically evaluate the literature; during this process, active participation, effective communication, and teamwork were also necessary.

The inaugural mock trial project in 2015 served as the final exam in a P1 evidence-based practice course. This project evolved over three developmental phases (Phase I, Phase II, and Phase III) from 2015 to 2019. The authors refer to the initial design and implementation of the mock trial project at a single Pharm.D. programme from 2015 to 2016 as Phase I. The latter was described previously in a published article (Rosenberg *et al.,* 2018) explaining that the rationale for the mock trial project was to focus on the desired and required competencies as stated by the IPEC (2011) expert panel, CAPE outcomes (2013), and ACPE standards (2016). To achieve this goal, the mock trial project aimed to require the active participation of all students on a team in every phase of the project, from research and strategy to development of arguments and roles and, ultimately, participation of all students so that each student has an active role in the mock trial (Rosenberg *et al.,* 2018). In addition, the project was deliberately designed to be student-directed, requiring students to be accountable and work as a team over the course of the term regarding research, planning, meetings, deadlines, and delegation of tasks among team members (Rosenberg *et al.,* 2018).

Further rationale provided that in contrast to a traditional debate, a mock trial presented opportunities to identify sufficient speaking roles for each student in the final assessment (the mock trial) (Rosenberg *et al.,* 2018). The mock trial offered students different roles with varying emphasis on communication and delivery (counsel: opening statement; direct exam; cross-exam; closing argument; witness: lay witness; expert witness; juror) and time limits for each speaking role, ensuring that all students get a chance to develop their individual communication skills (Rosenberg *et al.,* 2018). The cohort was divided into two trials (one topic per trial), and then each trial was divided into trial teams for (pro) or against (con) the controversial issue, which allowed for smaller mock trial teams as compared to membership of the entire cohort. Smaller mock trial teams also encouraged the more reserved or timid students to become more active participants on their respective teams over the term-long project (Rosenberg *et al.,* 2018).

In Phase II (2017-2018), the mock trial project enhancement was an expansion to incorporate faculty collaboration across two Pharm.D. programmes, including West Coast University (WCU) and the University of Maryland Eastern Shore (UMES), with parallel trials but in two different pharmacy courses (i.e. Evidence-Based Practice Public Health for Pharmacists). Collaboration between faculty at each programme (WCU, UMES) consisted of identifying two new trial topics (issues) for the mock trial each year (Rosenberg *et al.,* 2018). The authors considered a current controversy in healthcare, a current controversy concerning pharmacotherapy, or a current controversy impacting pharmacy practice

(Rosenberg *et al.,* 2018). Table I identifies the controversial mock trial topics debated between 2017 and 2019.

Subsequently, in 2019, the Phase III enhancement of the mock trial project integrated technology to enable student collaboration between the two programmes via a learning management system (LMS) (i.e. Blackboard Collaborate) and the continuing cross-institutional faculty collaboration. Specifically, because they shared a common goal and perspective on the assigned trial issue, students from the same trial and position ("*for*" or "*against*") at each programme (WCU and UMES) met online via the Blackboard Collaborate platform. In other words, this platform enabled WCU students and UMES students to meet virtually and engage with each other to share their literature-based results, identify the most robust evidence, and collaborate on developing trial strategies and evidence-based arguments for their positions at the trial. The integration of technology, which enabled the collaboration between students of two separate institutions, provided additional opportunities for both sets of students to practice and further develop skills in affective domains such as teamwork, communication, and professionalism.

Methods

A mock trial (courtroom-style debate) was implemented as part of a required course for first professional-year students at two institutions over three years (2017-2019). For each year, two separate mock trials were conducted with different topics (Table I) to accommodate the large cohort and maintain a small, manageable working group size. Students were divided into teams and given controversial topics to research and debate during mock trials. For each debate topic, students were randomly assigned to two teams with either a petitioner role (arguing for) or respondent role (arguing against) for the trial topic. Students enacted the roles of counsels and witnesses for their team position on the trial topic while serving as jurors in an alternate mock trial.

The mock trial project employed a self-directed learning approach along with formative and summative assessments during students' engagement in the project. Faculty first provided an orientation to the mock trial assignment. Students then prepared an outline for debate and gathered evidence to support their case. The formative assessment took place when the faculty reviewed and provided feedback for the outline and evidence. Students also had opportunities to ask questions, clarify points, and receive faculty input on the depth and breadth of the evidence gathered. Additionally, student teams could meet with faculty as needed for further feedback.

Summative assessments of learning occurred during the actual mock trials. Students collaborated with their team members to perform various roles, including counsels or witnesses for their team and trial. Faculty served as judges (faculty judges), while student teams on the second trial topic served as jurors (student jurors) for the alternate mock trial. Descriptions and details of the mock trial project, such as flow, organisation, roles, logistics, and resources, have been published previously (Rosenberg *et al.,* 2018). Over three years, controversial topics for the mock trials at both institutions were selected with input from participating course faculty, study investigators, and external collaborators. Table I presents the list of controversial topics used between 2017 and 2019.

During Phase III, in 2019, students from both pharmacy programmes collaborated by sharing their findings, reviewing the literature, and engaging in preparation for the mock trial, including, for example, identifying the strongest arguments based on the evidence pyramid hierarchy. In 2019, the mock trial collaboration study sought to assess students' acceptance of the technology used (Blackboard Collaborate learning management platform). To that end, the authors adapted and applied the Technology Acceptance Model (TAM) first described by Davis (Davis, 1989) to identify and then examine students' perceptions of the utility of the LMS to facilitate their collaboration with students from another pharmacy programme. This investigation utilised the TAM tool expressly because the research question sought to examine and understand the relationship between students' perceptions (perceived usefulness and perceived ease of use of technology) and students' usage behaviour (Shroff *et al.,* 2011). The TAM tool developed by Davis aims to explain an individual's intention to adopt information technology (Davis, 1989). Based on the TAM, a person with a more favourable "*attitude toward using*" a specific technology will have a stronger "*behavioural intention*" to use the technology in the future. Moreover, the user's "*attitude toward using*" that technology would be more favourable if the "*perceived usefulness*" and "*perceived ease of use*" were associated with the technology.

Table I: Controversial mock-trial topics debated between 2017 and 2019

Year	Trial topic.	Abbreviation
Mock-trial project: Faculty collaboration across two Pharm.D. programmes		
2017	Manufacturer discount coupons for prescription medications	"Manufacturer Discount Coupons"
	Primary care provider shortage	"PCP Shortage"
2018	Medical marijuana	"Medical Marijuana"
	Aid in dying practice with medication	"Aid In Dying" ("AID")
Mock-trial project: Faculty and student collaboration across two Pharm.D. programmes		
2019	Pharmacist prescribing authority for smoking cessation	"Smoking Cessation"
	Mandatory influenza vaccination for school age children	Mandatory Influenza Vaccines"
Virtual mock-trial competition ("fast track") between two programmes		
2019	Medical marijuana (2018 topic repeated)	"Medical Marijuana"

Subsequently, the TAM survey (Table II) included 20 statements on technology use in educational settings adapted from existing instruments (Shroff *et al.,* 2011; Alharbi & Drew, 2014). The first 17 items aligned with the four theoretical constructs (or categories) in the TAM framework, i.e. "*perceived usefulness*" (statements 1-6), "*perceived ease of use*" (statements 7-11), "*attitude toward using*" (statements 12-15), and "*behavioural intention to use*" (statements 16 and 17) (Davis, 1989). Cronbach's alpha values were > 9 for these four TAM categories, suggesting excellent internal consistency within each scale. The last three items in the survey were related to students' attitudes regarding the collaboration experience and the mock trial project itself. When responding to the survey electronically through Google Forms, students were asked to indicate their level of agreement with each statement using a 7-point Likert scale (from 1=strongly disagree to 7= strongly agree).

Descriptive analyses were conducted for the scores provided by all judges and jurors. For the TAM survey, the means and standard deviations of the survey responses were calculated. The referenced statistical analyses were performed using SPSS Statistics version 26.

Ethical statement

The evaluation of the implementation and impact of the mock trial received exempt approval from both programmes' Institutional Review Boards. Standards for reporting qualitative research (SRQR) were used (O'Brien *et al.,* 2014).

Table II: Descriptive results of 2019 Technology Acceptance Model (TAM)* survey

Survey question	Programme A Mean (SD)	Programme B Mean (SD)
1. Using the Blackboard Collaborate† (technology platform) enabled me to **engage in the cross-programme collaboration** with my peers at the second programme.	5.42 (1.57)	5.05 (2.10)
2. Collaborating with peers using the Blackboard Collaborate (technology platform) can **improve students' overall performance** in the mock-trial.	5.42 (1.48)	5.12 (2.01)
3. Using the Blackboard Collaborate platform **increased my productivity and preparation** for the mock-trial.	5.16 (1.72)	4.75 (2.01)
4. Using the Blackboard Collaborate platform **enhanced the effectiveness of my collaboration** with peers.	5.35 (1.47)	5.00 (2.00)
5. Using the Blackboard Collaborate platform **made it easier to collaborate** with peers when preparing for the mock-trial.	5.13 (1.65)	5.05 (1.97)
6. I found the Blackboard Collaborate platform **useful for collaborating with my peers** toward mock-trial preparation.	5.13 (1.73)	4.91 (2.10)
7. Overall, I found the Blackboard Collaborate platform **easy to use for collaboration** with my peers on the mock-trial.	5.32 (1.66)	5.69 (1.79)

Survey question	Programme A Mean (SD)	Programme B Mean (SD)
8. My interactions with the Blackboard Collaborate platform were **clear and understandable**.	5.06 (1.69)	5.58 (1.77)
9. I found the Blackboard Collaborate platform **flexible to interact with**.	5.26 (1.57)	5.37 (1.89)
10. **Learning to operate** the Blackboard Collaborate functions was **easy** for me.	5.26 (1.59)	5.83 (1.72)
11. I believe that it would be **easy in general to become skilled** at using the Blackboard Collaborate platform to collaborate in debate/mock-trial preparation.	5.19 (1.76)	5.75 (1.74)
12. I have a **generally favorable attitude** toward using the Blackboard Collaborate platform for debate/ mock-trial collaboration.	5.16 (1.68)	5.17 (1.85)
13. I believe it is **a good idea to use** Blackboard Collaborate platform for debate/ mock-trial collaboration.	5.29 (1.68)	5.11 (1.99)
14. I **like the idea of using** the Blackboard Collaborate platform for debate/ mock-trial collaboration.	5.13 (1.80)	5.17 (1.92)
15. I believe that using the Blackboard Collaborate platform was **generally helpful (beneficial)** for me in debate/ mock-trial collaboration.	5.16 (1.79)	4.91 (2.00)
16. I **recommend using the Blackboard Collaborate** platform for other collaboration with peers.	5.19 (1.76)	5.12 (1.92)
17. I **intend (plan) to use the Blackboard Collaborate** platform as often as possible for other collaboration with peers.	4.68 (1.92)	4.78 (2.07)
18. I am **satisfied with the general process and experience** of collaborating with students from another school in debate/mock-trial preparation.	5.13 (1.86)	4.57 (2.22)
19. The mock-trial itself **enhanced my critical thinking skills** such as those used in evidence-based decision making.	5.26 (1.81)	5.60 (1.80)
20. I would **recommend the mock-trial to other students** as a valuable learning activity.	5.16 (2.00)	5.49 (1.99)

(1= strongly disagree; 7= strongly agree); Programme A: n=31; Programme B: n= 65; SD: Standard Deviation

*Based on the Technology Acceptance Model, a person with more positive "*attitude toward using*" a specific technology will have a stronger "b*ehavioural intention*" to use the technology in the future. Moreover, a user's "*attitude towards using*" that technology would be more positive if there are "*perceived usefulness*" and "*perceived ease of use*" associated with the technology.

†Blackboard Collaborate is the proprietary name for a learning management platform offering a virtual classroom that "*allows learners to engage faculty, classmates, or peers, etc., from their desk, on the go, or wherever their busy lives take them*;" adaptable to learners' unique needs and is promoted as the "*classroom of the future*." (Blackboard Copyright 2021. Blackboard Inc.).

Results

Evaluation of student performance between 2017 and 2019

A total of 319 students participated in mock trials from 2017 to 2019, with 136 being from Programme A and 183 from Programme B. The number of faculty judges and student jurors who served in the panel varied between programmes due to differences in cohort sizes each year: 5-6 faculty judges and 10-12 student jurors rated the student performance for both the Petitioner and Respondent teams (Table III).

Faculty judge evaluation scores during the three years ranged from 83.3% to 97%. Irrespective of the trial topic, position, and programme, faculty judges consistently rated student performance higher than 85% for all but one student group. The exception was the Trial I Petitioners from Programme A in 2018, which had a student performance score of 83.3% (Table III).

The student juror evaluation scores during the 3-year span ranged from 87.5% to 100%. Student jurors rated student performances ≥ 90% for most mock trials, with three exceptions. In 2017, the Trial I Petitioners and Respondents at Programme A received performance scores of 85% and 87.5%, respectively. Also, for Trial II in 2017, the Respondents at Programme A received 87.5% as performance scores (Table III).

Notably, throughout the three years, faculty judge scores and student juror scores were comparable between Programmes A and B for most student groups, irrespective of the trial positions (pro or con) or topics. Nonetheless, a difference of > 5% was observed between the two programmes in the following four areas: (1) faculty judge scores for Trial I Petitioners in 2018; (2) student juror scores for Trial I Petitioners in 2017; (3) student juror scores for Trial II Petitioners in 2018; and (4) student juror scores for Trial II Respondents in 2019 (Table III).

Table III: Evaluation of students' mock-trial performance by faculty-judges and student-jurors

		Average judge evaluation (%) (Range 5-6 faculty judges/ trial)		Average juror evaluation (%) (Range 9-11 student jurors/ trial)	
		Programme A	Programme B	Programme A	Programme B
2017					
Trial I	Petitioner	88	90	85	100
(Shortage)	Respondent	91	93.3	87.5	91.7
Trial II	Petitioner	95	90	95	100
(Coupons)	Respondent	89	90	87.5	91.7
2018					
Trial I	Petitioner	83.3	92.5	96.8	98.2
(Marijuana)	Respondent	94.3	93.8	96.8	98.8
Trial II	Petitioner	86.0	89.5	91.8	98.7
(Suicide)	Respondent	86.3	89.2	96.8	93.7
2019					
Trial I	Petitioner	95	93.7	95	98.7
(Smoking)	Respondent	94	93.7	97.5	99.3
Trial II	Petitioner	97	92	95	95.7
(Flu vaccine)	Respondent	90	94	92.5	99

Student perceptions of collaboration between programmes in 2019

Ninety-six students from the 2019 mock trial cohort completed the TAM survey (Programme A: 31; Programme B: 65), yielding a response rate of 99%. Most survey items assessing technology acceptance reported a mean >5 on a 7-point Likert scale (Table II). Overall, students from both programmes reported the highest agreement on the questions asking whether the Blackboard Collaborate was easy to use for collaborating with peers (Statement 7; 5.57± 1.75), whether learning to operate the Blackboard Collaborate functions was easy (Statement 10; 5.65±1.69) and whether it would be easy to become skilful at using the Blackboard Collaborate (Statement 11; 5.57±1.76). The survey item with the lowest mean was Statement 17: "*I intend (plan) to use the Blackboard Collaboration system as often as possible for other collaborations with peers*" (4.75± 2.02).

Table II provides descriptive results of the 2019 TAM Survey for each programme. Differences greater than 0.5 between the two programmes were found in the following statements:
(1) Statement 8: interactions with the Blackboard Collaborate platform were clear and understandable;
(2) Statement 10: Learning to operate the Blackboard Collaborate functions was easy;
(3) Statement 11: it would be easy, in general, to become skilled at using the Blackboard Collaborate.
Two questions assessing students' attitudes toward the mock trial project itself showed an average rating above 5, irrespective of the school (Table II, Statements 19 and 20). However, students from Programme B reported an average rating of 4.57 for satisfaction with the general process and their experience of inter-institutional collaboration, while students from Programme A recorded 5.13 as their average satisfaction rating (Table II, Statement 18). Overall, the "*behavioural intention to use*" category recorded a mean of 4.95, while the other three TAM categories each had a mean above 5 (Table IV). The average rating for "*perceived usefulness*" was higher in Programme A (Programme A: 5.27 *vs* Programme B: 4.98), while Programme B had a higher rating in "*Perceived Ease of Use*" (Programme A: 5.22 *vs* Programme B: 5.65). A Pearson correlation coefficient above 0.8 was obtained between various categories ($p < 0.001$).

Table IV: Descriptive results of the TAM categories

TAM category	Prog. A mean (SD)	Prog. B mean (SD)	Overall mean (SD)
Perceived usefulness	5.27 (1.53)	4.98 (1.87)	5.07 (1.77)
Perceived ease of use	5.22 (1.58)	5.65 (1.63)	5.51 (1.62)
Attitude toward using	5.19 (1.67)	5.09 (1.84)	5.12 (1.78)
Behavioural intention	4.94 (1.77)	4.95 (1.95)	4.95 (1.88)

(1= strongly disagree; 7= strongly agree); Programme A: n=31; Programme B: n= 65; SD: Standard Deviation

Discussion

Results from the series of mock trials over three years (2017-2019) at Programmes A and B demonstrated that students at both institutions performed consistently well over the years. In other words, student pharmacists successfully delved into the literature for evidence, marshalling that evidence in support of their team's position and developing counterarguments against their opponents. The study results also indicated that this outcome held true irrespective of the trial topic. Students also evaluated favourably both the collaboration process and the mock trial experience.

Before this project, historically, mock trials were scarcely employed in pharmacy education, found only in isolated instances, and without repeated and deliberate assessment for competencies and outcomes; only one study previously reported having students as active participants in a mock trial albeit with roles that were scripted for the students by faculty or actual court cases (van Dusen, 1998; Broeseker & Jones, 1999; Spies, 2008; Bess *et al.,* 2016; Rosenberg *et al.,* 2018). Debates, however, have been employed in pharmacy education for active learning and assessment activities in various contexts (e.g. advocacy on ethical and legal issues, controversial policy issues in the US healthcare system, critical thinking and communication skills, evidence-based analysis and evaluation, and pharmacotherapy) (Lin & Crawford, 2007; Charrois & Appleton, 2013; Hanna *et al.,* 2014; Lampkin *et al.,* 2015; Peasah & Marshall, 2017; Toor *et al.,* 2017). Contrary to those previous examples in the literature, the mock trial project in the present study was deliberately designed, developed, and implemented to ensure that all students in the course have roles and to offer opportunities to develop students' skill sets in the "*affective domain*" (Rosenberg *et al.,* 2018).

Over consecutive iterations and expansion (2017-2019), this mock trial project successfully demonstrated evidence of consistently high student performance across the various iterations (successive years), courses (2), and topics (6) (Tables I & II). Notably, investigators deliberately selected timely, current, and contemporary controversies to attract and motivate students' curiosity and engagement in collaborative research inquiry and inspire a passion for the assigned position and argument. Faculty judges and student jurors evaluated competencies based on a standardised evaluation rubric (Appendix A), which paralleled the competencies described in CAPE 2013 (Medina *et al.,* 2013) and ACPE Standards 2016 (Accreditation Council for Pharmacy Education, 2015), including cognitive and affective domain outcomes such as critical thinking, teamwork, communication, and professionalism.

Through the evolution of the mock trial project from 2017 to 2019, the investigators also identified potential future applications of the mock trial utilising novel modalities to connect students from different programmes. As described, the 2019 initiative piloted a student collaboration across two Pharm.D. programmes by using the technology of a learning management platform (Blackboard Collaborate). The authors believe that the success of the mock trial enhancement with this technology in 2019 (Phase III) suggested and supported the implementation of a virtual trial format as a potential future direction. Fortuitously, the authors' experience with a learning management system and virtual mock trials the previous year enabled a smooth transition to virtual mock trials when the COVID-19 pandemic forced a sudden transition from in-person to remote learning in March 2020, just weeks before the mock trials scheduled in April, which would otherwise have been held in-person. Following that experience in 2020, implementing a mock trial competition between pharmacy programmes, whether virtually or in-person, could be envisioned as a future and further expansion of the mock trial project, which could be investigated as a scholarship of teaching and learning.

Based on the authors' investigations and experiences, the mock trial project has been and is adaptable to different contexts and modalities, such as integration of a mock trial within a course, as a co-curricular or extracurricular activity, and implementation in a virtual environment (Broeseker & Jones, 1999). Indeed, recent literature investigated mock trial use in various healthcare contexts and practice areas, e.g. simulation learning, to offer experience in evidence-based practice (Song & Jang, 2023). Mock trials have also been used to promote interprofessional education in health sciences (Ghimouz *et al.,* 2021) and teach child abuse (van Wylick & Davidson, 2011) or ethics in medical education (Coelho *et al.,* 2017). They were used as a learning tool in medical residency (Drukteinis *et al.,* 2014; Lennon *et al.,* 2020), nursing education for competency development (Troxel, 2012), continuing education (Centrella-Nigro & Flynn, 2012), professional development (White, 2015), psychiatry law (Glancy, 2016), and even advanced medical studies for fellows (Foley *et al.,* 2017) and surgeons (Juo *et al.,* 2019).

With the emergence of technological advances, mock trial use has even reached the metaverse, which bridges reality and virtual reality (Lee *et al.,* 2023). The use of mock trials in the virtual realm should come as no surprise since several virtual programme offerings in pharmacy education have emerged during the

pandemic and continue to this day. Therefore, as a teaching and learning tool, the mock trial project remains a viable active learning strategy, whether in-person or in a virtual format.

Limitations

In considering study limitations, the authors note that student performance in the mock trials was based on their summative scores. Moreover, while criteria in the affective domain were incorporated within the scoring rubric (Appendix A), student performance scores relating to a specific affective domain were not presented. A future study could further investigate student performance related to a specific affective domain or domains and/or specific criteria within an affective domain. The authors also acknowledge that the Technology Acceptance Model (TAM) is only one option among various theories for studying online learning and collaboration. Another future study direction would be to apply other relevant theories, such as the Community of Inquiry (CoI) framework (Garrison *et al.,* 2001), to examine the adoption of technology by students in the context of a mock trial project. Additionally, the present study was based on investigations at two institutions. Admittedly, the characteristics of the two institutions (Programme A: private, for-profit and Programme B: public, HBCU) and the courses (Evidence-Based Practice and Public Health for Pharmacists) where the mock trials were implemented were quite different. The differences between the two institutions suggest the mock trial project could be adapted to different instructional environments. However, it is also possible that the study results may not be replicated in other schools/programmes, and, therefore, more evidence on the implementation of the mock trial project should be gathered. The authors invite the expansion of the mock trial project to further examine and assess its adaptability and sustainability across various institutions and courses.

Conclusion

Participation in the mock trial project offered students the opportunity to practise and refine foundational competencies deemed vital to the pharmacy profession, including literature evaluation (critical thinking), argument (communication), collaboration (teamwork), professionalism (court decorum), and presentation of evidence. The evaluations of faculty judges and student jurors consistently indicated that students performed well in presenting their trial arguments and positions and that they actively demonstrated the knowledge and skills needed to evaluate and critique literature.

As assessed by faculty judges and student jurors in the mock trial, student participants demonstrated an ability to "*perform*" well insofar as developing affective domain competencies. Based on the experience with the three described phases, the authors believe that the mock trial can be replicated or adapted, and implemented in other courses or institutions to support faculty teaching and student learning. Expanded implementation of this project across various courses and institutions can serve to further validate its adaptability and sustainability in diverse institutions and courses.

Conflict of interest

The authors declare no conflicts of interest or financial interest in any product or service mentioned in this article, including grants, employment, gifts, stock holdings or honoraria.

Source of funding

This project was funded by an intramural faculty research grant awarded by West Coast University in 2018.

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Appendix A: Faculty judge and student juror evaluation form

2020 Mock Trial JUDGE/JUROR Evaluation Form

___Petitioner: What evidence-based arguments SUPPORT (Insert Trial Topic) ?

___Respondent: What evidence-based arguments caution AGAINST (Insert Trial Topic)?

Evidence	Strong evidence (3.0 points)	Good evidence (2.5 points)	Some evidence (1.5 points)	Little evidence (1 point)	No evidence (0 point)	Pts
KNOWLEDGE/ CONTENT [Domain 1] HOW WELL did students demonstrate foundational knowledge/ content on this topic?						/3.0
LEVEL OF EVIDENCE (literature, references, citations) [Domain 1] HOW WELL (to what degree) did students provide literature citation(s)/ reference(s)?						/3.0
APPLY/ INTERPRET/ COMPARE/ CONTRAST/ ANALYZE [Domain 1] HOW WELL did students APPLY, INTERPRET, COMPARE/ CONTRAST, ANALYZE applicable literature?						/3.0
VISUAL AIDS/ EDUCATE AUDIENCE [Domain 3] HOW WELL did students use VISUAL AIDS to educate audience?						/3.0
COMMUNICATION: DELIVERY & ARTICULATION [Domain 3] HOW WELL did students deliver and articulate their arguments?						/3.0
ACTIVE LISTENING / RESPONSES [Domain 3] HOW WELL did students actively listen and actively respond?						/3.0
PROBLEM SOLVING & CRITICAL THINKING [Domain 3] HOW WELL did students demonstrate problem solving and critical thinking?						/3.0
LEADERSHIP and TEAMWORK [Domain 4] HOW WELL did students demonstrate leadership and teamwork?						/3.0
PROFESSIONALISM [Domain 4] HOW WELL did students demonstrate professionalism?						/3.0
OVERALL PERFORMANCE [Domain 4] HOW WELL did students perform OVERALL?	STRONG and EXCELLENT PERFORMANCE - EXTREMELY WELL PREPARED (3 points)	VERY GOOD PERFORMANCE - WELL PREPARED (2.5 points)	GOOD PERFORMANCE - PREPARED (1.5 points)	LOW LEVEL PERFORMANCE - NOT ADEQUATELY PREPARED (1 point)	INADEQUATE PERFORMANCE - UNPREPARED - NO EVIDENCE (0 points)	/3.0
Total Points						**/30**

Pharmacy Education (2024) 24(1) 40 - 47
https://doi.org/10.46542/pe.2024.241.4047

RESEARCH ARTICLE

Telepharmacy knowledge, attitude, and experience among pharmacy students in Indonesia: A cross-sectional study

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Keywords
Attitude
Experience
Knowledge
Pharmacy student
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Abstract

Background: The advancement of technology in healthcare services has given rise to telepharmacy. The success of telepharmacy depends on the knowledge, attitude, and experience of pharmacy students. However, telepharmacy is relatively new in the Indonesian pharmacy education system. **Methods:** This cross-sectional study was conducted using an online questionnaire to evaluate pharmacy students' knowledge, attitude, and experience related to telepharmacy. **Results:** The questionnaire was completed by 442 pharmacy students. Among them, 97.96% demonstrated a high level of knowledge about telepharmacy, and 96.60% had a positive attitude toward it. However, 85.97% of students had limited experience with telepharmacy. While there was a significant correlation between knowledge and attitude, no such correlation was observed between attitude and experience. **Conclusion:** The findings revealed that pharmacy students had high knowledge and attitude, but limited experience with telepharmacy. Additionally, there is a significant correlation between knowledge of telepharmacy and a positive attitude towards its use. To better prepare future pharmacists to provide effective telepharmacy services, it is essential to integrate telepharmacy practice models into the curriculum.

Introduction

The evolution of technology in healthcare services has transformed how patient care is delivered (Iyanna *et al.*, 2022; Stoumpos *et al.*, 2023). In the field of pharmacy, this transformation is formed by the concept of telepharmacy (Poudel & Nissen, 2016). Telepharmacy involves delivering pharmaceutical care to patients in remote areas using telecommunications and information technologies, with pharmacists typically not physically present at the point of patient care (Alexander *et al.*, 2017). This approach significantly improves pharmacists' accessibility in underserved areas affected by economic or geographic challenges, leading to improved patient satisfaction, clinical outcomes, and quality of life (Baldoni *et al.*, 2019).

As healthcare and technology converge, it's crucial to assess how pharmacy students who will become future pharmacists perceive telepharmacy (Frenzel & Porter, 2023). The knowledge and perception of pharmacy students are determining factors in the success of telepharmacy (Patel, 2021). Prior reports have indicated that integrating telepharmacy into pharmacy education improves students' comprehension of drug therapy issues and patient care plans. There is also a need to develop strategies for technology-based education and training among students (Elnaem *et al.*, 2022). To understand telepharmacy practically, students require curriculum integration and hands-on experience. This exposure to telepharmacy is crucial as it allows students to adopt a patient's perspective,

offering valuable insights for their future telepharmacy practice (Park *et al*., 2022).

The Ministry of Health has issued regulations for implementing remote health services (Ministry of Health of The Republic of Indonesia, 2021). These regulations support the practice of telepharmacy in pharmacy services, including dispensing, patient education, and counselling (Sasanti *et al*., 2022). However, telepharmacy remains a relatively new technology and is not widely integrated into the pharmacy education system in Indonesia. Previous research on pharmacy students in Ethiopia has shown limited knowledge and perceptions of the telepharmacy system (Tegegne *et al*., 2023). In contrast, senior pharmacy students in Malaysia generally possess adequate knowledge, positive perceptions, and a readiness to implement telepharmacy services in their future pharmacy practice. However, they express concerns about potential increased workloads and a lack of incentives associated with the widespread adoption of telepharmacy practice models (Elnaem *et al*., 2022). Information on the knowledge and attitude toward telepharmacy is scarce and often conflicting.

Additionally, there is a lack of existing studies on the experience of telepharmacy among pharmacy students in Indonesia. Therefore, this study aimed to assess the knowledge, attitude, and experience related to telepharmacy.

Methods

Study design and population

This study used a cross-sectional design, distributing online questionnaires via Google Forms to students in the Department of Pharmacy at a public university in Central Java province in July 2022. Data were collected by surveying all active students in the Department of Pharmacy, including undergraduate pharmacy students and pharmacist professional students. The total number of respondents was 442 students.

Study questionnaire

Data for this study was collected through a questionnaire on telepharmacy, compiled from various sources, including Poudel & Nissen (2016), Alexander et al. (2017), Albarrak et al. (2021), FIP (2021), the Ministry of Health of The Republic of Indonesia (2021), and Elnaem et al. (2022). The questionnaire began with questions related to respondent characteristics, including age, gender, and programme of study in the Department of Pharmacy.

The questionnaire comprised a total of 54 questions, categorised into 15 knowledge questions, 13 attitude questions, and 26 experience questions. Respondents could choose between "true" and "false" for knowledge questions. Meanwhile, attitude questions offered answer choices of "*strongly agree*," "*agree*," "*disagree*," and "*strongly disagree*". Experience questions were answered with "*ever*" or "*never*".

To assess validity, a content validity test involved six validators: four academics in the pharmacy department who are also pharmacists, an academician in the public health sector, and a pharmacy professional student. The item-content validity index (I-CVI) was 0.99 for the knowledge questionnaire, 0.97 for the attitude questionnaire, and 0.85 for the experience questionnaire, meeting the minimum I-CVI requirement of 0.83 for six validators (Yusoff, 2019). For reliability, Cronbach-alpha values were calculated for each questionnaire: 0.831 for the knowledge questionnaire, 0.897 for the attitude questionnaire, and 0.932 for the experience questionnaire. The questionnaire is considered reliable, with Cronbach-alpha values falling between 0.7 and 0.95 (Tavakol & Dennick, 2011).

Data analysis

The data were analysed descriptively to assess the respondents' characteristics, knowledge levels, attitudes, and experiences related to telepharmacy. Knowledge questions were scored 1 point for "*true*" and 0 points for "*false*". Attitude responses of "*strongly agree*," "*agree*," "*disagree*", and "*strongly disagree*" were scored as 4, 3, 2, and 1 points, respectively. For experience, '*ever*' and '*never*' were scored as 1 and 0 points. The total knowledge, attitude, and experience scores were 15, 52, and 26, respectively. To calculate the scores for each knowledge, attitude, and experience question, the total score for each question was divided by the maximum possible total score and then multiplied by 100%.

For categorising knowledge, attitudes, and experience, the criteria set by Elhadi et al. (2021) were as follows: scores ≤ 49% were considered low, 50%-70% were average, and ≥ 71% were regarded as high. To examine the correlation between knowledge level and attitude, as well as attitude and experience, Spearman's rank correlation analysis was used due to the non-normal distribution of the data ($p < 0.05$). The analysis results were considered significant if $p < 0.05$.

Ethical approval

The study received official approval from the Faculty of Health Sciences ethics committee at Jenderal Soedirman University (Reference Number: 2706/EC/KEPK/IV/2022). Participant agreement for study involvement was obtained through a Google Form. Those who provided consent were eligible to complete the research questionnaire. Before answering the questionnaire, participants were given an introduction outlining the study's objectives and methods, along with a consent section ensuring anonymity and voluntary participation in the survey.

Table I: Characteristic of respondents

Characteristic of respondents	Frequency (%)
Gender	
Male	67 (15.16%)
Female	375 (84.84%)
Age (years old)	
18-20	189 (42.8%)
21-23	217 (49.1%)
>23	36 (8.1%)
Pharmacy students programme	
Undergraduate pharmacy	337 (76.24%)
Pharmacy professional	105 (23.76%)

Results

A total of 442 pharmacy students participated in this study, comprising 337 undergraduate pharmacy students and 105 pharmacy professional students. The education system in Indonesia primarily comprises a four-year undergraduate degree followed by a one-year pharmacy professional programme. The curriculum and learning outcomes align with the academic standards set by the Association of Indonesian Pharmacy Higher Education. Undergraduate programmes typically emphasise general pharmacy skills and knowledge, covering pharmaceutical sciences and clinical pharmacy. The pharmacy professional programme, a pre-registration programme before becoming a qualified pharmacist, provides additional practice training and skills (Cokro *et al*., 2021). The majority of respondents were female (84.8%), and their ages ranged from 21 to 23 years old (49.1%) as shown in Table I.

The student's knowledge, attitude, and experience of telepharmacy

Overall, 97.96% of students demonstrated high knowledge of telepharmacy, while 96.60% showed a positive attitude toward it. However, regarding telepharmacy experience, 85.97% of students had a low level of experience, as shown in Table II. The analysis of knowledge levels revealed that the majority of students had good knowledge of "*Telepharmacy increases access to pharmacy services in areas with a limited number of pharmacists*," with an average score of 98.64%, as shown in Table III. Regarding attitudes toward telepharmacy, the highest average score (91.86%) was observed for students' opinions on the importance of pharmacists' knowledge of information and communication technology (telecommunications) for telepharmacy, as shown in Table IV. Furthermore, when it came to experience, the majority of students (average score 63.35%) reported having adequate electronic equipment, such as cell phones, for telepharmacy, as shown in Table V.

Table II: Categories of pharmacy students' level of knowledge, attitude, and experience related to telepharmacy

Categories	Knowledge n=422 (%)	Attitude n=422 (%)	Experience n=422 (%)
High	433 (97.96%)	427 (96.60%)	17 (3.85%)
Average	9 (2.04%)	14 (3.17%)	45 (10.18%)
Low	0 (0%)	1 (0.23%)	380 (85.97%)

Table III: Knowledge-based questions

Questions	Average scores (%)
Pharmacists and patients meet face to face on telepharmacy	83.03
Knowledge related to information and communication technology (telecommunications) is needed by pharmacists to conduct telepharmacy	99.32
Telepharmacy can be done using *video conference* (e.g *zoom* atau *Google Meet*)	96.15
Telepharmacy can be done using digital health applications (e.g halodoc, alodoc, etc)	97.74
Purchases of narcotic drugs can be served by electronic prescription	81.90
Purchases of psychotropic drugs can be served by electronic prescription	74.43
Telepharmacy allows pharmacists to confirm electronic prescriptions with doctors	96.83
Telepharmacy allows pharmacists to provide recommendations for overcoming drug-related problems in electronic prescriptions to doctors	96.61
Pharmacists can not gather patients' information by telepharmacy	85.52
Monitoring patients' medications can be done by telepharmacy	93.44
Drug counselling can be done by telepharmacy	98.42
Providing information on drugs and medical devices can be done by telepharmacy	97.51
Telepharmacy increases access to pharmacy services in areas with a limited number of pharmacists	98.64
Telepharmacy reduces the number of direct patients visit to pharmacy service facilities	87.78
Telepharmacy is a legally recognised pharmacy service	95.93

Table IV: Attitude-based questions

Questions	Average scores (%)
Telepharmacy allows me to get access to pharmacy services	88.40
I can use telepharmacy anytime and anywhere as long as I have a telecommunications or internet signal	90.33
I feel I can have good communication with pharmacists via telepharmacy	81.33
Telepharmacy allows to improve the quality of my communication with the pharmacists	82.47
I can save time on visits to pharmacy service facilities if I use telepharmacy	89.76
I can save on medical costs if I get pharmacy services via telepharmacy	80.77
The confidentiality of my information can be maintained through telepharmacy	78.96
Telepharmacy makes it possible to increase the quality of the pharmacy services that I receive	81.39
Telepharmacy may improve my medication adherence	77.15
In my opinion, pharmacists' knowledge of information and communication technology (telecommunications) is important for telepharmacy	91.86
In my opinion, it is important to provide knowledge related to telepharmacy to pharmacy students to help utilise telepharmacy in the future	91.06
I need adequate electronic equipment (e.g cellphone) for telepharmacy	88.24
I think that the existing laws and regulations are sufficient to regulate the technical implementation of telepharmacy	69.17

Table V: Experience-based questions

Questions	Average scores (%)
I received drug counselling by the phone from the pharmacist	14.93
I received drug counselling via video conference (eg. Zoom or Google Meet) from the pharmacist	8.60
I received drug counselling via a messaging service application (e.g WhatsApp) from the pharmacist	31.67
I received drug counselling via a digital health service application (halodoc, alodoc, etc.) from the pharmacist	35.07
I received medication monitoring by the phone from the pharmacist	10.86
I received medication monitoring via video conference (eg. Zoom or Google Meet) from the pharmacist	3.39
I received medication monitoring via a messaging service application (e.g WhatsApp) from the pharmacist	18.55
I received medication monitoring via a digital health service application (halodoc, alodoc, etc.) from the pharmacist	13.57
I received information regarding medication by the phone from the pharmacist	21.04
I received information regarding medication via video conference (eg. Zoom or Google Meet) from the pharmacist	14.48
I received information regarding medication via a messaging service application (e.g WhatsApp) from the pharmacist	34.16
I received information regarding medication via a digital health service application (halodoc, alodoc, etc.) from the pharmacist	45.70
I asked the pharmacist for drug-related information by the phone	18.78
I asked the pharmacist for drug-related information via video conference (eg. Zoom or Google Meet)	7.69
I asked the pharmacist for drug-related information via a messaging service application (e.g WhatsApp)	34.16
I asked the pharmacist for drug-related information via a digital health service application (halodoc, alodoc, etc.)	28.51
I asked the pharmacist for general health information (other than medications) by the phone	15.61
I asked the pharmacist for general health information (other than medications) via video conference (eg. Zoom or Google Meet)	8.14
I asked the pharmacist for general health information (other than medications) via a messaging service application (e.g WhatsApp)	24.21
I asked the pharmacist for general health information (other than medications) via a digital health service application (halodoc, alodoc, etc.)	23.98
I bought medicine with an electronic prescription	16.97
I bought medicine without a prescription (over the counter-medication) via telepharmacy	23.08
I bought medical equipment (such as a thermometer, oxygen mask, etc.) via telepharmacy	18.78
I bought other medical materials (such as masks, handscoons, etc.) via telepharmacy	30.54
I provided adequate electronic equipment (e.g cellphone) for telepharmacy	63.35
I studied the laws and regulations related to telepharmacy	42.99

To measure the correlation between knowledge and attitude, as well as attitude and experience, Spearman's rank correlation analysis was conducted. There was a significant correlation between knowledge and attitude (p = 0.011). However, there was no significant correlation between attitude and experience (p = 0.092). These results are presented in Table VI.

Table VI: Correlation of level of knowledge, attitude, and experience of pharmacy students related to telepharmacy

Variables	*p-value*
Knowledge to Attitude	0.011[i]
Attitude to Experience	0.092

[i]statistically significant ($p < 0.05$)

Discussion

This study examined the knowledge, attitude, and experience of pharmacy students regarding telepharmacy. To the authors' knowledge, this is the first study specifically measuring the knowledge, attitude, and experience of pharmacy students in this area. Generally, pharmacy students demonstrated a high level of knowledge and a positive attitude toward telepharmacy. The COVID-19 pandemic likely contributed to increased knowledge due to exposure and the demand for technology in healthcare (Malhotra *et al*., 2020). However, this study's findings differ from those of Ethiopian pharmacy students, where 86.4% of students were unaware of telepharmacy systems, resulting in poor knowledge about telepharmacy (Tegegne *et al*., 2023). Additionally, a study on Malaysian senior pharmacy

students found that 61% viewed telepharmacy favourably, as it can improve their ability to provide patient care interventions (Elnaem *et al*., 2022). Similarly, pharmacy students in North Dakota showed a positive attitude toward telepharmacy and telehealth, believing these services positively impact patient care (Frenzel & Porter, 2023).

The finding also highlighted the pharmacy students' understanding of the importance of telepharmacy in improving access to pharmacy services in areas with a shortage of pharmacists. In regions lacking pharmacists, obtaining prescriptions and accessing critical services becomes more challenging. Telepharmacy mitigates the impact of pharmacist shortages, especially in rural areas where clinical pharmacy services are delayed and prescription errors associated with pharmacists increase (Ahmed *et al*., 2023).

This study revealed that pharmacy students highly value pharmacists' knowledge of information and communication technology (telecommunications) for telepharmacy. Telecommunications and information technologies serve as the foundation for telepharmacy implementation (Ameri *et al*., 2020). To prepare students for telepharmacy, pharmacy programmes should incorporate technology-related subjects into their curricula (Frenzel & Porter, 2023). The integration of telepharmacy simulation into university programmes in the United States, specifically for prescription verification and patient counselling activities, has led to an increased perception among students regarding the use of telepharmacy for patient education. Additionally, students expressed a high level of confidence in their ability to verify prescription medications and counsel patients through telepharmacy, albeit with varying degrees of confidence (Porter *et al*., 2022).

Another study conducted at North Dakota University, focusing on communication via telepharmacy, indicated that students demonstrated the ability to counsel patients through this technology. However, their performance was noted to be better in face-to-face consultations, suggesting the need for additional exposure to telepharmacy in the learning programmes (Skoy *et al*., 2015). Students should learn how to adapt their skills to provide effective patient care, including prescription verification, patient consultation and education, interprofessional interactions, and the use of electronic health records. These services can be delivered using telecommunication technologies when face-to-face interactions are not possible (Frenzel & Porter, 2021). Telecommunication technology in telepharmacy has demonstrated effectiveness in enhancing the quality of pharmacy services (Baldoni *et al*., 2019). Telepharmacy applications have been shown to reduce medication errors and alleviate acute complaints in elderly patients within 30 days post-hospital discharge (Rebello *et al*., 2017). Furthermore, in tuberculosis management, the use of digital technology, including video-observed treatment, telephone calls, or SMS reminders, presents a promising approach to improve medication adherence and treatment outcomes. This involves providing personalised feedback to patients (Ridho *et al*., 2022).

There was a statistically significant correlation between knowledge and attitude regarding telepharmacy among pharmacy students, which is consistent with previous findings that prior knowledge of telepharmacy is significantly linked to a positive attitude toward its use (Omran *et al*., 2021). Continuing professional education is an effective way to enhance understanding and foster a positive attitude toward telepharmacy. To better prepare future pharmacists for providing telepharmacy services, pharmacy colleges should integrate telepharmacy practice models into their curricula. Furthermore, by attending lectures, seminars, and conferences, pharmacy students can enhance their understanding and readiness for utilising telepharmacy (Ahmed *et al*., 2023).

The findings of this study suggest a gap between knowledge and attitude toward telepharmacy compared to its experience among pharmacy students. Pharmacy students demonstrated unfavourable scores in telepharmacy experience. Despite having adequate electronic equipment (e.g. cell phones) for telepharmacy, they rarely received medication monitoring via video conference (e.g., Zoom or Google Meet) from pharmacists. The majority of pharmacists do not prefer video conferencing due to its technical demands and limited access to technology, making it challenging for them to utilise video conferencing in telepharmacy. As a result, only a small number of patients receive telepharmacy services via video conference (Cubo *et al*., 2021; Sasanti *et al*., 2022; Ilma *et al*., 2023)

No association was observed between attitude and the experience of telepharmacy in pharmacy students. When pharmacy students engage in telepharmacy, they actively participate as patients to receive pharmacy services. However, for community pharmacists in Indonesia, there was a correlation between attitude and experience in providing pharmacy services through telepharmacy (Ilma *et al*., 2023). Effective telepharmacy requires support from both pharmacists and patients (Sasanti *et al*., 2022). Interestingly, despite patients willingness to use telepharmacy, the majority of patients in Indonesia

(79.8%) have never used telepharmacy services (Tjiptoatmadja & Alfian, 2022).

Strength and Limitations

This study is the first to examine the knowledge, attitude, and experience of pharmacy students toward telepharmacy in the country, offering valuable insights for future telepharmacy implementation. However, the online survey and the relatively small number of participants may have led to findings that are not fully representative of the general population.

Conclusion

The majority of pharmacy students exhibited high knowledge and a positive attitude toward telepharmacy, but their experience of telepharmacy was unfavourable. Additionally, there is a significant correlation between knowledge of telepharmacy and a positive attitude towards its use. To better prepare future pharmacists for providing effective telepharmacy services, it is essential to integrate telepharmacy practice models into the curriculum.

Conflict of interest

None

Source of funding

Lembaga Penelitian dan Pengabdian Masyarakat (Institute of Research and Community Service), Jenderal Soedirman University (Competency Improvement Research, 2022 with grant number T/739/UN23.18/PT.01.03/2022).

Acknowledgements

Authors acknowledge Lembaga Penelitian dan Pengabdian Masyarakat (Institute of Research and Community Service), Jenderal Soedirman University, for funding this research (Competency Improvement Research, 2022 with grant number T/739/UN23.18/PT.01.03/2022). The authors also would like to thank the pharmacy students who participated in this study.

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Pharmacy Education (2024) 24(1) 48 - 53
https://doi.org/10.46542/pe.2024.241.4853

RESEARCH ARTICLE

Student perspectives on peer education using a virtual platform to enhance advanced pharmacy practice experiences (APPE)

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Keywords
COVID-19
Online platform
Pharmacy education
Pharmacy student learning
Virtual conference

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Abstract

Background: The COVID-19 pandemic caused dramatic disruptions in the education of pharmacy students who graduated in 2022. As an additional active learning opportunity at a New York City hospital site with multiple preceptors and faculty, a monthly student-led virtual educational conference was implemented. The objective of this study was to assess student perspectives on the implementation of a virtual peer education conference. **Methods:** Between May 2021 and May 2022, a total of twenty-eight students participated as presenters or attendees. All students completed a 13-item survey to evaluate the impact their participation in the virtual conference had on their overall learning and how similar opportunities could impact their future learning experiences. **Results:** When asked to rate on a scale from 1 (did NOT improve at all) to 5 (greatly improved my learning), 93% (26/28) of students rated their change in learning after attending the student-led conference as a four or five. Students identified that participation enhanced their drug/disease state knowledge, improved their presentation skills and/or improved their critical thinking and clinical application skills. **Conclusion:** In the future, advanced pharmacy practice experiences (APPE) can consider the inclusion of peer education through an online platform as a strategy to facilitate learning in pharmacy programmes.

Introduction

In March 2020, a New York City (NYC) COVID-19 lockdown caused educational institutions to transition to fully remote instruction, causing dramatic disruptions in the education of pharmacy students expecting to graduate in 2022. A study from the end of 2021 assessed the impact the COVID-19 pandemic had on graduating pharmacy students in NYC and reported high levels of personal and school related stress leading to lack of motivation and hindered learning ability. In a reflection paper as a part of the study, students conveyed that while being frontline workers, they felt isolated from their friends and their learning, and with time, found it harder to freely communicate with others. Financial strain and loss were identified as additional burdens for many students during this time, creating an overall tone of tragedy and despair, all while in their most demanding year of professional studies (Elbeshbeshy, Gim & Quattrocchi, 2021). At the University of Alberta, located in Canada, a population of 53 pharmacy students in various years of the programme were asked to reflect on how the COVID-19 pandemic affected their pharmacy education. Results showed that remote delivery of coursework negatively impacted pharmacy student learning. Students expressed that this shift to remote learning was "*detrimental to their education*" as it was difficult to follow and retain material from home. There was no "*bouncing back and forth*" of ideas between classmates (Nagy *et al.,* 2021). The negative feedback in response to remote coursework delivery was also attributed to

the rapid adjustment instructors were forced to make, some with little to no training on the software they were suddenly required to use (Gillis & Krull, 2020).

Considering the lack of face-to-face education that the pharmacy students of the class of 2022 received, additional learning opportunities have been trialled to compensate for the hindered learning these students experienced. A study that assessed the impact of peer teaching on student scores and confidence on a clinical examination within a pharmacy programme proved that peer-guided learning positively impacts students in their professional education. First-year pharmacy students who attended a peer-led clinical skills training session led by upperclassmen completed a post-training survey to re-assess their confidence in their clinical skills. Students felt more comfortable discussing and collaborating with peers as opposed to faculty. Furthermore, students who attended the session scored higher on their Objective Structured Clinical Examination (OSCE) than those who did not receive training from their peers (Cole *et al.,* 2018). Another study found that peers are better able to relate to student challenges and that peer education provides an opportunity for students in the healthcare field to get training and knowledge at a more comfortable level (Lawson *et al.,* 2019).

As an additional active learning opportunity at the hospital site in NYC, a monthly student-led education conference was implemented among a cohort of pharmacy students on the Advanced Pharmacy Practice Experience (APPE) rotation. A core aspect of this conference was that it focused on peer learning since the presenters, being the students, were delivering educational presentations to their peers. Student presenters were given their assignment during the first week of their rotation and had three weeks to identify a topic and develop their presentation. Pharmacy faculty or preceptors reviewed and approved topics for presentation and provided detailed feedback prior to the presentation at the conference. Student presentations included elements such as interactive Kahoot games for North American Pharmacist Licensure Examination (NAPLEX) practice questions, patient case discussion and analysis, topic discussions about expanding disease state knowledge and presentations on new drug approvals. The virtual platform on which this student-led conference was conducted allowed students to deliver content in a didactic style but also allowed them to have ample interaction with their peers and exchange ideas to help facilitate their learning. The utility of small-group online learning was examined at Harvard Medical School in the spring of 2020, where students were divided into "*virtual homerooms*" to supplement their radiology clerkship. Students responded that small group virtual learning environments were conducive to their clinical training as future healthcare professionals. Despite being virtual, students conveyed they were able to form interpersonal connections with peers with the added convenience of being able to social distance and avoid commuting time and expenses (Goldenson *et al.,* 2022). Since virtual learning helps overcome the barriers of social distancing, the virtual setting was chosen to implement the student-led educational conferences at the institution. The purpose of this study was to assess student perspectives on the implementation of a virtual peer education conference. While peer-assisted learning is a useful tool in professional education, proven to benefit cognitive development, psychomotor development and self-confidence, its role has not been extensively studied in pharmacy education (Lawson *et al.,* 2019).

Methods

Pharmacy students on an APPE rotation at an NYC medical centre between May 2021 and May 2022 participated in a student-led educational conference as described above. Each APPE rotation was a total of four weeks long, and the student-led educational conference was held during the last week of the rotation after having completed activities such as journal club presentations, case presentations, and topic discussions throughout their rotation. Conferences were held on an online platform for each rotation period in order to comply with social distancing precautions and to be easily accessible to all students participating in the student-led conference. Students developed 30-minute presentations with preceptor feedback for the educational conference. Attendees included all pharmacy students at that rotation site, preceptors, and pharmacy staff. Immediately following the presentation, all students, both presenters and attendees, received a link to complete a 13-item survey to evaluate the impact peer education had on their overall learning and how similar opportunities could impact their future learning experiences.

The 13-item survey asked the following:

1. When did you complete your rotation?
2. When is your expected year of graduation?
3. Did you participate in peer education on a different APPE rotation BEFORE this rotation.
4. What disease states/topics did your peers present on?
5. How did participating in peer education help to improve your learning? Select from the following: enhanced my drug/disease state knowledge, improved

my own presentation skills, and/or improved my critical thinking and clinical application skills.

Student responses to the following statements were measured using a Likert scale with responses ranging between strongly disagree, disagree, neutral, agree or strongly agree:

6. Peer education should be offered during all APPE rotations when possible.
7. I think peer education is a good way to increase my learning during APPE rotations.
8. I am confident in providing education and facilitating discussion among pharmacists, pharmacy residents, preceptors, etc. at my APPE site.
9. I feel confident in peer education as the presenter/facilitator.
10. I feel confident in peer education as an audience member.
11. I am willing to provide peer education and facilitate discussion with my peers.
12. Participating in peer education at my rotation helped to improve my learning.

Lastly, students were asked:

13. How did this conference change your learning after attending the conference from a scale of 1 (did NOT improve at all) to 5 (greatly improved my learning)?

At the end of the survey, students were also given an opportunity to voice any additional comments or feedback about their experience at the end of the survey. Survey responses were analysed using descriptive statistics to assess student perspectives on the impact participation in the conference had on learning. Categorical data and Likert scale responses were reported as percentages. This study received IRB exemption from the institution, and student participation in the survey was voluntary and anonymous. No personal student information was collected. Informed consent was detailed upon entry into the electronic survey.

Results

A total of 28 students participated in the student-led conference between May 2021 and May 2022, with 15 students as presenters and 13 as attendees. Each month, students discussed topics such as infectious diseases, cardiology, psychiatry, health literacy, and endocrinology. All 28 students who participated completed a survey. As depicted in Figure 1, only 29% of students participated in peer education on a different APPE rotation. Responses displayed in Figure 2 demonstrate that 86% (24/28) of students reported that their drug/disease state knowledge was enhanced, 79% (22/28) improved their own presentation skills, and 54% (15/28) improved their critical thinking and clinical application skills as a direct impact of the student-led conference. Figure 3 displays student responses to questions asked on a Likert scale of strongly disagree, disagree, neutral, agree or strongly agree. 86% (24/28) of students agreed or strongly agreed that peer education should be offered during all APPE rotations when possible. 96% of the participants (27/28) thought that peer education is a good way to increase learning during APPE rotations. 79% of the participants (22/28) felt confident in peer education and facilitating discussions with healthcare professionals at the APPE site. 68% of the participants (19/28) felt confident in peer education as the presenter or facilitator, and 93% (26/28) felt confident in peer education as an audience member. 86% of the participants (24/28) were willing to provide peer education and facilitate discussion with their peers. 96% (27/28) found that participating in peer education did improve their learning. Overall, 93% (26/28) of students rated their change in learning after attending the student led conference as a 4 or 5 from a scale of 1 (did NOT improve at all) to 5 (greatly improved my learning).

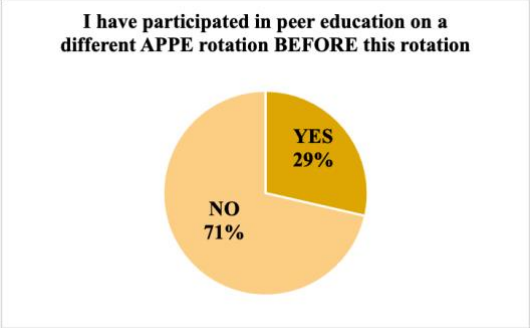

Figure 1: Students identified if they have had peer education opportunities in their prior APPE sites

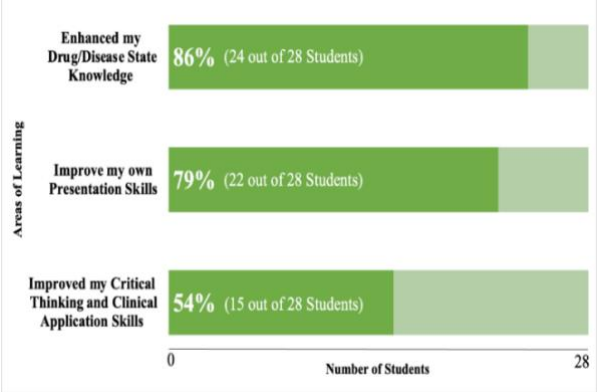

Figure 2: Students identified how peer education supplemented their learning

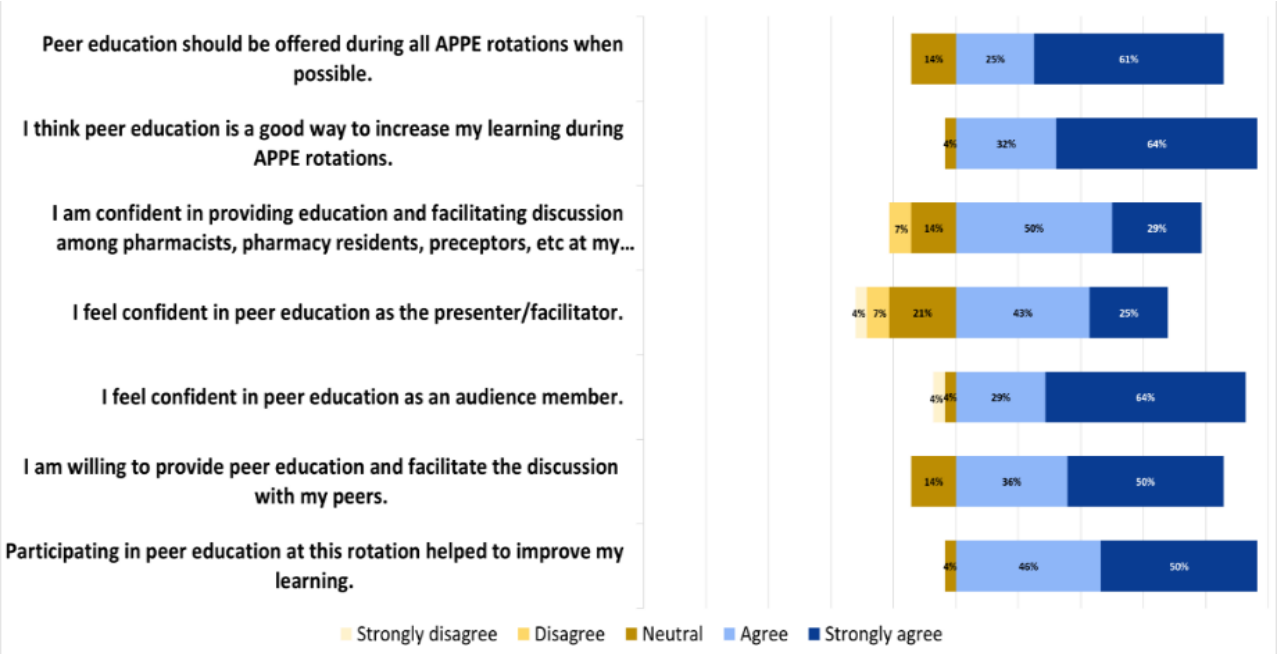

Figure 3: Student responses after presenting or attending the student-led conference

Discussion

The implementation of peer education as an additional active learning component for the class of 2022, a class of pharmacy students whose education was hindered by the height of the COVID-19 pandemic, enriched the pharmacy practice experience. These virtual educational student-led conferences allowed students to not only hone their clinical knowledge but also build the interpersonal skills that are essential to the role of a pharmacist. The findings of the study are similar to those of prior studies on peer education in pharmacy programmes (Cole *et al.,* 2018, Lawson *et al.,* 2019) and provide additional insight into the benefits of virtual peer education. Furthermore, the Accreditation Council for Pharmacy Education (ACPE) requires Doctor of Pharmacy programmes to include teaching methods that engage and push for collaborative learning (Accreditation Council for Pharmacy Education, 2015). Implementation of a virtual peer education programme achieves this ACPE requirement.

Prior studies have highlighted concerns associated with online delivery platforms as effective tools in education. For example, a study done in 2022 voiced concern about the "*underdeveloped communication skills associated with online delivery platforms*" (Morling *et al.,* 2022). Another found that due to the pandemic, students were initially intimidated by a virtual environment in which they struggled due to a lack of motivation and uncertainty about how to be an effective student online (Morling *et al.,* 2022). Furthermore, a study that assessed students and faculty at two different Doctor of Pharmacy programmes during the early stages of the COVID-19 pandemic identified a shared sentiment of "*imposter syndrome*" among student pharmacists at the institutions surveyed. Imposter syndrome, in their case, aligned with feelings of intellectual fraudulence as students felt they were not being held to the same standards as previous graduating classes especially since ACPE made experiential requirements for graduation more lenient for students in school during COVID-19. In association with this imposter phenomenon, students had a lack of professional identity and a lack of confidence in their abilities as future health care practitioners (Boyle *et al.,* 2022).

To address the difficulties students faced, including the rushed transition to a remote platform, lack of interpersonal connections, and negative sentiments of "*imposter syndrome*," the student-led conference was modelled to allow students to ease back into their interaction with peers, preceptors and other health care professionals. Students, both presenters and attendees, learned from each other through the interactive presentations that allowed for ample discussion and exchange of ideas and built confidence. Survey responses revealed that students learned from each other by engaging in a non-conventional component of an APPE experience. The responses support the implementation of such conferences through virtual platforms that would allow for a larger audience and increased participation to bridge the gaps

in knowledge that occurred because of the sudden transition to remote learning during the pandemic.

The survey results also convey that students participating in the conference were able to leave with an increased sense of confidence. While confidence is an emotional component, it is a component that plays a big role in the success of any aspiring clinician. A study from September 2022 that evaluated the confidence of students in their 3rd professional year prior to the start of APPEs revealed that the class of 2022 reported the "*not confident*" response five times more than the class of 2021 (Mirzaian *et al.,* 2022). Once again, it is the class of 2022, a pharmacy class that lacked in-person instruction due to the changes their curriculum endured as a result of the COVID-19 pandemic, that stands out among other graduating classes. It is imperative that aside from clinical knowledge and critical thinking skills, the confidence and interpersonal skills needed to interact with other members of the health care team are honed during APPE rotations. In 2021, a study exploring APPE readiness by evaluating the perspectives of APPE students, faculty and faculty site directors underscored that APPE readiness was dependent on relationship-building and workplace practices that orient and support students. Both students and preceptors value relationships which may aid in increasing confidence prior to the start of APPEs and during (Gruenberg *et al.,* 2021). Positive relationships foster the comfortable environment students need in order to be able to express any hardships and identify roadblocks in their learning. This study helps identify that clinical knowledge, while important, must be built alongside other factors that contribute to APPE readiness (Gruenberg *et al*., 2021). Through the virtually led educational conference, students were able to have meaningful interactions with their peers, faculty, and other preceptors at the hospital, allowing them to get to know the professionals at their APPE site and make it a comfortable learning environment going forward. As such, these conferences can be a useful tool for preceptors to shape their rotations to optimise pharmacy student learning.

Overall, this study demonstrates students' positive experience with peer education and provides valuable insight into the importance of the learning environment that students require in order to better understand and retain the material. In a peer-assisted learning study from 2018, a low-stress learning environment was established between first-year and upperclassmen pharmacy students. The study results concluded that a student's professional development requires a productive yet comfortable surrounding that may not be offered if only left to the confines of a class (Morling *et al.,* 2022). The study tried to emulate this type of environment by using live video so that peers could see one another, allowing for the comfortability that provides comprehensive back-and-forth conversations.

Limitations of this study include a small sample size, a short study time frame and limited generalisability. This study was conducted over a time frame of one year in which only a small group of students participated in the conference and responded to the survey. The study was also limited to the class of 2022, which may impact the generalisability of the benefit of peer learning on APPE to groups of students who have experienced disruptions in learning. Additionally, no baseline survey was done to serve as a comparator that would reveal student perspectives and sentiments prior to engaging in the student-led peer educational conference. The inclusion of a control group consisting of pharmacy students from another graduating class would help further evaluate the benefit of peer education in the APPE curriculum.

Despite these limitations, the study highlights peer education through a virtual platform as a way to enhance student well-being and assurance. Ultimately, this study can be treated as a model for future studies that will examine the effects of peer education through a virtual platform with a larger sample size of pharmacy students. Further research done across multiple institutions and including students from different graduating classes can help underscore the findings of this study and support the inclusion of this type of learning component within APPEs.

Conclusion

Data from the student survey evaluations supports that the use of virtual peer education is beneficial for pharmacy student learning during APPE rotations. Student involvement in peer education after having experienced a lack of in-person learning was shown to improve student confidence as presenters and communicators and enhance disease state knowledge and critical thinking skills, all key to the profession of pharmacy. The inclusion of virtual peer education is a feasible way for APPE sites to incorporate more collaborative learning for student pharmacists. In the future, APPE rotations can consider the inclusion of peer education opportunities to foster these benefits.

Conflict of Interest

The authors declare no conflict of interest.

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Pharmacy Education (2024) 24(1) 54 - 78
https://doi.org/10.46542/pe.2024.241.5478

RESEARCH ARTICLE

Antibiotic knowledge assessment questionnaire in undergraduate pharmacy students: A Rasch analysis of validity evidence

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Keywords
Antibiotic
Knowledge
Questionnaire
Rasch analysis

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Abstract

Background: Antibiotic knowledge is crucial for undergraduate pharmacy students who are future healthcare professionals. However, a valid and reliable instrument to assess their knowledge is scarce. This study aimed to develop and validate an Antibiotic Knowledge Assessment Questionnaire (AKAQ). **Methods:** The AKAQ had three domains and 29 items, encompassing general antibiotic knowledge, antibiotic resistance, and antibiotic stewardship. Rasch analysis was used to assess psychometric properties, including validity parameters (item and person fit and structural validity), reliability (person and item reliability, Cronbach's Alpha value), item-person interaction, and item bias, using differential item functioning (DIF) based on tems. **Results:** This study included 500 undergraduate pharmacy students from 90 Indonesian universities. The validity of the questionnaire was demonstrated, except for one item. Person means infit and outfit for MNSQ were 1.02 and 0.95, whereas ZSTD were 0.11 and 0.08, respectively. Items means infit and outfit for MNSQ were 1.01 and 0.96, while ZSTD were 0.11 and -0.23. Item and person reliabilities were acceptable at 0.99 and 0.68. Cronbach's alpha reliability was acceptable at 0.71. Two items were biased by term. **Conclusion:** The AKAQ is a valid, reliable, and standard instrument for assessing the antibiotic knowledge levels of undergraduate pharmacy students.

Introduction

Antimicrobial resistance (AMR) is a global health issue (O'Neill, 2014), directly responsible for 1.27 million deaths in 2019, as estimated by a recent global analysis (Murray *et al.,* 2022). The impact of AMR is particularly pronounced in low-middle-income countries (O'Neill, 2014) compared to middle- or high-income countries due to weak laboratory capacity, inadequate governance of health systems, limited health information systems, and constrained resources (Iskandar *et al.,* 2021). Notably, Indonesia ranked 70th of 76 countries in the total amount of antibiotic consumption measured in DDD/1000 inhabitants per day, according to the pharmaceutical sales data between 2000 and 2015 (Klein *et al.,* 2018).

Recognising the critical role of proper education and training in addressing AMR, this work focuses on pharmacy students as future healthcare professionals. Some studies suggest that enhancing pharmacy students' knowledge of AMR and stewardship programmes can influence the broader population's behaviour towards responsible antibiotic use (Bond,

2005; Smith & Olin, 2010; Burns *et al.,* 2020). However, research data on antibiotic knowledge and antibiotic stewardship among pharmacy students is scarce; in developing countries, it is limited to Pakistan (Hayat *et al.,* 2021), Saudi Arabia (Kandasamy *et al.,* 2020), Uganda, Kenya, and Tanzania (Lubwama *et al.,* 2021), Sri Lanka (Sakeena *et al.,* 2018), and Malaysia (Rajiah *et al.,* 2015). Moreover, recent studies measured knowledge levels of antibiotics among the general population in Indonesia (Widayati *et al.,* 2012; Karuniawati *et al.,* 2021; Yunita *et al.,* 2022; Sinuraya *et al.,* 2023). Importantly, this research gap has not been addressed in the Indonesian context, where Rasch analysis was utilised. Unlike the commonly used factor analysis (Liu *et al.,* 2019; Karuniawati *et al.,* 2022; Tohan *et al.,* 2023), Rasch offers distinct advantages in evaluating structural validity (Mallah *et al.,* 2020). Factor analysis has drawbacks, such as the parametric basis of component analysis and the formation of "*difficulty factors*", which may falsely suggest multidimensionality with ordinal scales (Nunnally & Bernstein, 1994). In contrast, Rasch's analysis comprehensively assesses item function, differential item functioning, and local item dependencies (Bond *et al.,* 2020; Linacre, 2021). Rasch generates an ordered item collection, tests unidimensionality, ensures generalisability, considers the potential variability in how respondents perceive the distances between different response options, and identifies poorly functioning items through unexpected replies, providing valuable advantages (Bond *et al.,* 2020).

This study aimed to develop a valid and reliable instrument to measure Indonesian undergraduate pharmacy students' general knowledge of antibiotics, antibiotic resistance, and antibiotic stewardship.

Methods

Study design, participants, and setting

A web-based cross-sectional quantitative study was performed in Indonesia from February to May 2022 using the Antibiotic Knowledge Assessment Questionnaire (AKAQ), a self-administered instrument created on Google Forms. The questionnaire was distributed to Indonesian undergraduate bachelor of pharmacy students (an education programme before professional pharmacist education) from different terms and universities.

Ethics approval and informed consent

The study received ethical approval from the Health Research Ethics Committee of Universitas Harapan Bangsa before it was conducted (Reference No. B-LPPM-UHB/726/02/2022). The respondents were informed online about the nature of this study; they consented to participate by starting the AKAQ. The anonymity of the students was assured to protect their identification.

Sample size and recruitment

Comrey and Lee have categorised the quality of sample size for questionnaire validation based on the number of samples, i.e. the sample size of 50, 100, 200, 300, 500, and ≥1000 should be regarded as very poor, poor, fair, good, very good, and superb, respectively (Comrey & Lee, 2013). Therefore, the sample size was set to 500 participants to achieve an adequate level. This study applied a random sampling method to choose participants from Indonesian universities. Lecturers were approached from different universities to distribute the AKAQ to their students from different years of the bachelor programme. Data were transformed from the Google Form database into Statistical Package for the Social Sciences version 26.0 (IBM, 2019) to be exported into Winsteps version 5.2.1.0 software (Linacre, 2022). Rasch analysis was conducted, which is a psychometric analytic method that analysed participant responses to the AKAQ questionnaire to determine instrument validity and scale functioning. A Rasch model was used to analyse sum scores from these ordinal responses due to the dichotomous response structure to calculate interval-level estimates that represent person locations (i.e. person ability) and item locations (i.e. the difficulty of a specific question (item) to provide a correct or positive response) on a linear scale that represents the latent variable (logit scale) (Laliyo *et al*., 2022).

Instrument development

The four steps for developing the questionnaire consisted of framework development, item (question) generation, item screening, and pre-testing (Boateng *et al.,* 2018).

Framework development

Established questionnaires (Jamshed *et al.,* 2014; Inácio *et al.,* 2017; Lubwama *et al.,* 2021; Park *et al.,* 2021) and antimicrobial stewardship guidelines (World Health Organization, 2019; World Health Organization, 2021) were used for the framework development phase.

Item generation

Building upon the framework, the AKAQ was categorised into two parts. The first part is intended to collect information about participants' demographic

characteristics such as sex, age, and term. The second part assessed participants' knowledge of antibiotics and included three domains evaluating general antibiotic knowledge (Inácio *et al.,* 2017; Katzung & Vanderah, 2020), antibiotic resistance (Jamshed *et al.,* 2014; Lubwama *et al.,* 2021), and antibiotic stewardship (World Health Organization, 2019; Park *et al.,* 2021; World Health Organization, 2021). It comprised close-ended questions with the options of "*agree*," "*do not agree*," or "*do not know*." The scales were dichotomised, with true and false answers scored 1 and 0, respectively. Similar to wrong answers, the "*do not know*" option was graded 0.

Item screening

Item screening involved four experts (pharmacists with experience in teaching antibiotic-related topics to pharmacy students) who checked the relevance of the items. This process focused on establishing the content validity of the AKAQ items and entailed the exclusion of some questions that did not meet the predetermined criteria. The content validity of the AKAQ was assessed through the content validity index (CVI) approach. Excellent content validity should be composed of Item-CVI (I-CVI) to measure expert agreement on individual item's relevance, Scale-level CVI/Universal Agreement (S-CVI/UA) to gauge unanimous expert agreement on item relevance, and Scale-level CVI/Average (S-CVI/Ave), an average score indicating the degree of expert agreement on item relevance and appropriateness at the scale or questionnaire level, with threshold values of ≥0.78, ≥0.8, and ≥0.9, respectively (Shi *et al.,* 2012). The content of all the AKAQ items achieved the validity parameters. Finally, a questionnaire was constructed in Indonesian and comprised 29 items distributed over three domains, i.e. general knowledge (9 items), AMR (10 items), and antimicrobial stewardship (10 items) (Appendix A).

Pre-testing

The final stage of instrument development involved a pre-testing (face validity test) to examine the clarity of the items. Previous research suggested 30 people for pre-testing (Perneger *et al*., 2015). The AKAQ was distributed to 30 pharmacy students to confirm questionnaire readability and content before collecting data on a larger sample size. Questionnaire item correction and amendment were addressed according to their feedback. The latest version of the polished pre-testing question was utilised as the final questionnaire for validation (Appendix B).

Construct validity

The Rasch measurement analysis was used to investigate the AKAQ validity based on construct validity. This psychometric technique was developed to improve the precision of instrument (questionnaire) constructions, evaluate instrument quality, and investigate respondents' performances (Boone *et al*., 2014). The Rasch analysis accurately and precisely explained the difficulty level of an item (i.e. question), detected the suitability and interaction of items and persons (item-person maps), identified outliers (person misfit), and detected item bias (e.g., differential item functioning (DIF)) to ensure that all items consistently measure the same concept across different term (Boone, 2016; Sumintono & Widhiarso, 2014). Rasch measurement was based on the Joint Maximum Likelihood Estimation equations whereby the raw data were converted to interval data (logits)(Linacre, 1998; Bon, Fox & Lacey, 2020). Psychometric parameters of the AKAQ, which were assessed consisting of validity parameters (item and person fit, structural validity); reliability (person and item reliability, Cronbach's Alpha value; person and item separation); item-person interaction; and item bias using DIF based on term (see Table I).

Table I: Rasch measurement properties and assessment criteria

Rasch measurement	Acceptable range	Definition
Person and item fit analysis	The person and item fit were measured using infit and outfit mean-square (MNSQ) and z-standard (ZSTD). The acceptable range of infit and outfit MNSQ are 0.5–1.5 (Sumintono & Widhiarso, 2015; Bond *et al.,* 2020). The value of 1.6 is accepted if an item has a positive point measure correlation (PTMA) (Sumintono & Widhiarso, 2015; Bond *et al.,* 2020) Meanwhile, the acceptable range for infit and outfit of ZSTD is −2 to +2, even though this threshold can be ignored if the sample size is more than 200 (Azizan *et al.,* 2020)	Person fit analysis was used to determine the validity of the person-response relationship. It can help to identify participants with atypical response patterns (for example by selecting the same answer for all the items). Item fit analysis was conducted to see whether the items in the AKAQ instruments can measure the knowledge about antibiotics in pharmacy undergraduate students. The item should be improved or deleted if a particular item is a misfit. Item fit analysis was displayed on a bubble chart to show measures and fit values graphically.

Rasch measurement	Acceptable range	Definition
Structural validity (unidimensionality)	Raw variances of >30% (Linacre, 1998; Chou & Wang, 2020) Eigen values of <3 (Linacre, 2021)	Structural validity measurement aimed to ascertain whether all items collectively measure the same domain of knowledge trait. The parameters of unidimensionality were assessed to confirm the structural validity of the AKAQ. Unidimensionality was evaluated by raw variances explained by items and unexplained variances in first contrast or Eigen values.
Reliability	Person and item reliability of >0.67 (Fisher, 2007) Cronbach's alpha value of >0.6 (Taber, 2018)	Reliability is measured to indicate the reproducibility of the measure (Linacre, 2021), (Bond & Fox, 2013).
Separation coefficients for individual items and persons	Item separation value is expected as >3 (Linacre, 2021). Person separation values are 1.50 (acceptable), 2.00 (good), and 3.00 (excellent)(Duncan *et al.,* 2003; Canto-Cerdan *et al.,* 2021)	The separation coefficient was measured to explore how well the different items distinguish the participants' ability and how well the individual participants distinguish the items' difficulty levels. The higher the separation values, the better the separation.
Item-person interaction	Item-person interaction is displayed in the Wright map (see Fig. 2 in results) using the same linear scale (logit scale). It was assessed from a distance between the mean (M) value of items' difficulty and participants' ability. The closer the two values, the better, with a difference of 0 between the two values denoting a perfect match between the items' difficulty and participants' ability. A difference of 1> logit indicates a non-matching difficulty level between the question/item and the participants' ability (Cantó-Cerdán *et al.,* 2021)	Wright Map (Item-Person Correlation) is intended to explore how well the distribution of test items' difficulty concerning participants' knowledge levels.
Differential Item Functioning (DIF)	Negligible (|DIF | 0≥0.43 logits); Slight to Moderate (|DIF | ≥0.43 logits) and prob (|DIF| = 0 logits) ≤0.05 (2-sided); Moderate to Large (|DIF | ≥0.64 logits) and prob(|DIF| ≤0.43 logits) ≤0.05 (2-sided) (Zwick *et al.,* 1999)	DIF is conducted to check item bias based on the term in which we assume that students from different terms will have different scores on the AKAQ (Linacre, 2021). Term classification is divided into two groups, i.e. undergraduate pharmacy students in the first to fifth terms and sixth to twelfth terms, but undergraduate pharmacy education in Indonesia should be noted to have a standard study period of 4 years or 8 terms, while students above 8 terms are students who are late in completing their studies.

Statistical analysis

This study used Winsteps version 5.2.1.0 software (Linacre, 2022) and Statistical Package for the Social Sciences (SPSS) version 26 (IBM, 2019) for statistical analysis. Winsteps was used to perform Rasch analysis to check the validity and reliability of the AKAQ and to run a DIF analysis. The SPSS version 26 (IBM, 2019) was used to run the descriptive statistics of participants' characteristics.

Results

Data collection and screening

This study enrolled 500 participants from 90 Indonesian universities (Table II). Of the total sample, 85% were females, 59% were 20-23 years old, and 30.4% were in the fourth term. The majority (69.0%) were from universities in the western region of Indonesia, where most universities are located.

Table II: Demographics of participants (n=500)

Baseline characteristics	Frequency	%
Sex		
Female	425	85%
Male	75	15%
Age		
<20 years old	117	35.4%
20-23 years old	294	58.8%
>23 years old	29	5.8%
Term		
1st – 5th Term	282	56.4%
6th – 12th Term	218	43.6%
University participants		
West Region (69 Univ.)	345	69.0%
Central Region (20 Univ.)	126	25.2%
East Region (1 Univ.)	29	5.8%

AKAQ validity and reliability

The Person and Item Fit Parameters are summarised in Table III. Overall, the means of infit (weight) and outfit (unweight) mean square (MNSQ) for person fit measurements were acceptable, with values of 0.93 and 1.00, respectively. The means of infit and outfit z-standard (ZSTD) were acceptable, with values of 0.03 and 0.06, respectively. However, approximately 11% of participants (n = 56) were misfits (Appendix C) because their infit and outfit MNSQ were outside the acceptable range (lower threshold: 0.5, and upper threshold: 1.6 as long as the value of PTMA is positive) (Sumintono & Widhiarso, 2015; Bond *et al.,* 2020). Thus, the response pattern of those students could not be predicted well by the Rasch model. The misfit persons were excluded; hence, the MNSQ and ZSTD person values after exclusion were acceptable, with values of 0.95 and 1.02 and 0.11 and 0.08, respectively. Some persons were misfits based on the ZSTD threshold (n = 20). However, the number of samples is 444 (>200); therefore, this ZSTD threshold can be ignored (Azizan *et al.,* 2020).

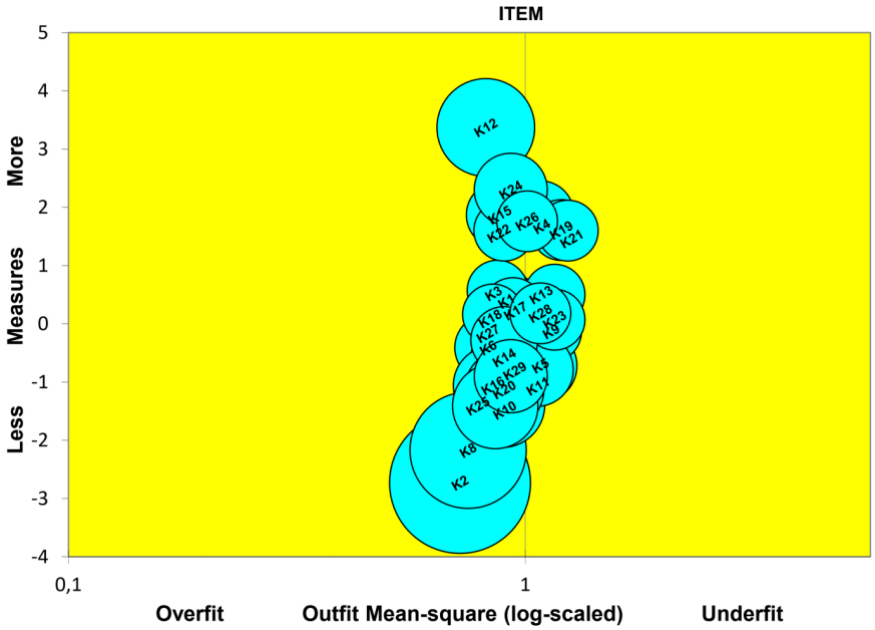
Table III: Summary of Rasch parameters for AKAQ

	Persons	Person (After deletion)	Item (question)	Item (After deletion K7)
N	500	444	29	28
Mean measure	0.78	0.75	0.00	0.16
SD	0.80	0.69	1.61	1.41
SE	0.04	0.04	0.31	0.27
Mean:				
Infit MNSQ	1.00 (Range: 0.43-1.69)	1.02 (Range: 0.61-1.69)	1.00 (Range:0.82-1.16)	1.01 (Range:0.89-1.16)
Infit ZSTD	0.03 (Range: -2,85-2.5)	0.11 (Range: -1.90-2.44)	0.09 (Range:-2.72-4.46)	0.11 (Range:-2.72-4.46)
Outfit MNSQ	0.93 (Range: 0.14- 2.73)	0.95 (Range: 0.50-1.58)	0.93 (Range: 0.17-1.24)	0.96 (Range:0.73-1.24)
Outfit ZSTD	0.06 (Range:-1.33-2.80)	0.08 (Range:-1.13-1.27)	-0.30 (Range:-2.55-2.85)	-0.23 (Range:-2.55-2.85)
Reliability (Rasch)	0.73	0.68	0.99	0.99
Reliability (Cronbach's Alpha)	0.71			
Separation coefficient	1.65	1.44	10.83	11.40
Unidimensionality				
Raw variance by measure	34.9%			
Unexplained variance in 1st contrast	2.84%			

*SD= Standard Deviation, SE= Standard error, MNSQ= mean-square, ZSTD= z-standard, K7= Knowledge Question no.7

The means of infit and outfit were 1.00 and 0.93 for MNSQ and -0.30 and 0.09 for ZSTD, respectively, for the item fit. However, one misfit item was identified based on the MNSQ outfit value (Appendix D), i.e. item K7 (MNSQ: 0.17; ZSTD: −2.18). Thus, this item was removed (Appendix E). The deletion of item K7 was able

to increase MNSQ and ZSTD outfits (Table III). Furthermore, ten misfit items were found (Appendix D) according to the range of ZSTD infit and outfit value (−2–2), but this threshold can be ignored because the sample size is >200 (Azizan *et al.,* 2020). The distribution of item fit orders for the 28 valid items is shown in Figure 1, while the initial item fit order involving item K7 is shown in Appendix E.



The Y axis is the Joint Maximum Likelihood Estimation (item) Measure; the X axis is the Item Fit Mean Square (Linacre, 2021); Overfit (x > 1.50); Outfit (x = 0.50–1.50). Each bubble represents an item whose size is proportional to the standard error of item difficulty calibration. Well-fitting items are close to the central vertical line. Items should preferably be the closest possible to a modelled value of 1 for infit and outfit MNSQ, regardless of plotting the interplay of fit and items and fit and persons (Bond *et al.,* 2020).

Figure 1: Bubble chart of item fit order

Construct validity (unidimensionality)

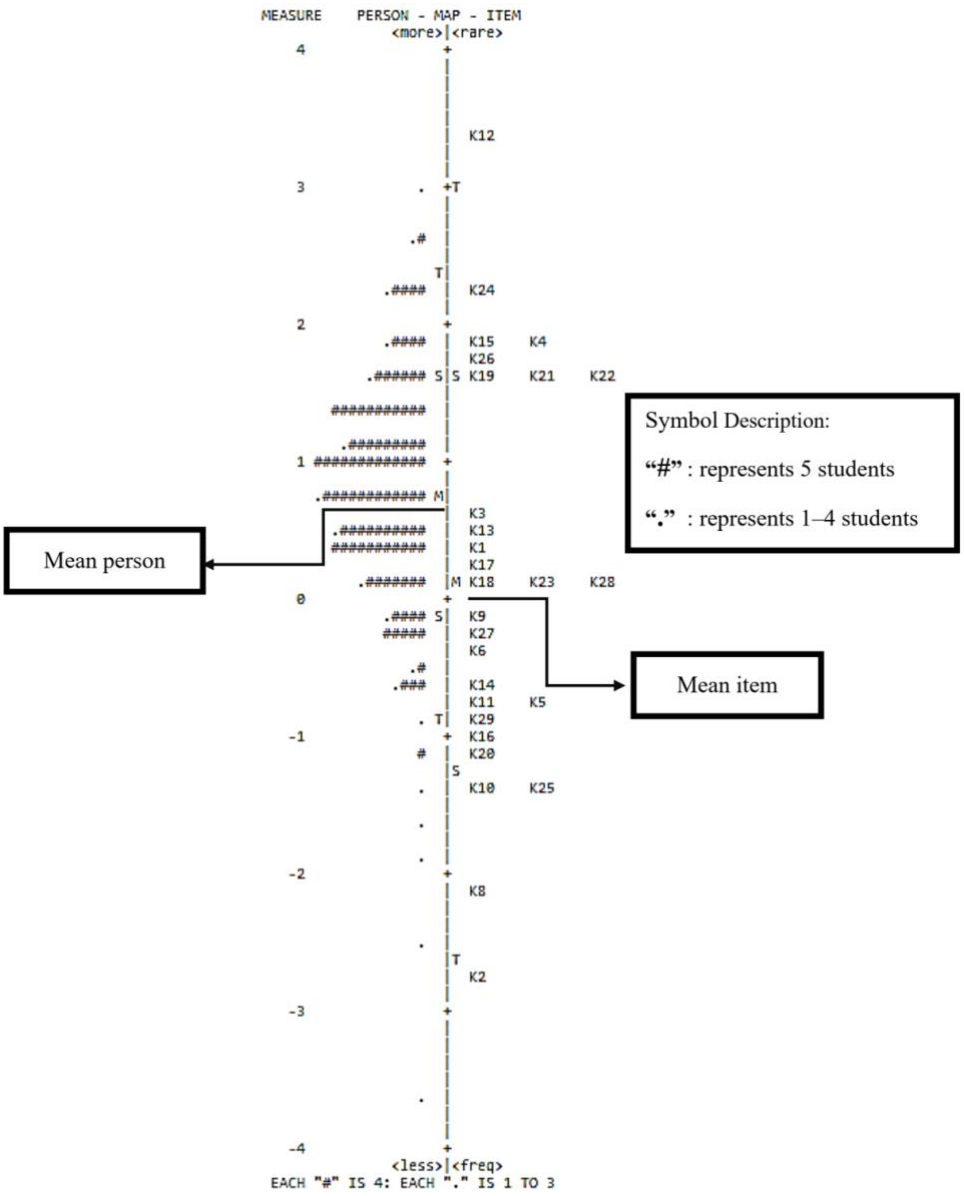
The structural validity of the AKAQ was further examined using unidimensionality. The results reached an acceptable threshold at >30% (Linacre, 1998; Chou & Wang, 2010) (33.4%), indicating that the instrument achieved the unidimensionality criteria. Moreover, the unexplained variance for the first contrasting values was <3% (2.71%). The unexplained variance confirms no random noise in the instrument used in this study.

Reliability

The Rasch parameter generated acceptable criteria for person and item reliabilities, i.e. 0.7 and 0.9, respectively. Additionally, Cronbach's alpha was above the acceptable threshold, i.e. 0.6 (Taber, 2018) (Table III). Overall, the AKAQ exhibited acceptable criteria for the Rasch reliability parameter (Fisher, 2007; Taber, 2018). Moreover, the person and item separations were acceptable, i.e. 1.44 and 20.08, respectively. These values supported the idea of the AKAQ reliability (Wright & Master, 1982; Boone, 2016).

Item-person interaction

The item-person Wright map (Figure 2) was used to check whether the items in the AKAQ were neither too challenging nor too easy for the participants. In this study, the participants' indicators were located higher than the items' indicators, reflecting that pharmacy students had a higher ability than the difficulty level of the test items (Linacre, 2021). However, the difference between the mean person measure and the mean items measure was <1 logit (0.51 logits), which indicates that the difficulty level of the question/item remained suitable with the participants' ability (Linacre, 1998; Linacre, 2021). Hence, item K2 (Bacterial infections can be treated with antibiotics) was identified as the easiest item and item 12 (Beta-lactamases are enzymes produced by bacteria that break open the beta-lactam ring) was the hardest item (Boone, 2016).



The right-hand side shows the 28 items of the questionnaire from the easiest (K2, bottom indicator) to the most difficult one (K12, top indicator); the left-hand side locates the person's ability measured along with the items. The higher the symbol, the better the test results. M in the right- and left-hand sides indicate the mean item difficulty and the mean person ability, respectively (Canto Cerdan *et al*., 2021).

Figure 2: Wright map (Item-Person Correlation)

Moreover, the Wright map shows that students have >50% chance (p = 0.5) of correctly answering an item when their indicator is above the item's indicator. The 50% chance (p = 0.5) occurs when the indicators align, indicating comparable difficulty levels between the item and students' ability. Conversely, students have <50% (p < 0.5) chance to correctly answer the item if the person's indicator is located the item's indicator.

Differential Item Functioning (DIF) analysis

DIF analysis by term (Figure 3) indicated that items K6 (DIF:0.79; Prob:0.0045) and K19 (DIF: −0.67; Prob: 0.0198) fell into the moderate to large DIF category (Zwick *et al.,* 1999) (Appendix F). Items K6 and K19 were found to be easier for students in the first to the fifth terms compared to those in the sixth to the twelfth terms. However, these items were not removed because they are relevant for assessing antibiotic-related knowledge, supported by the content and construct validity results. Moreover, dropping these items might lower the reliability and validity of the AKAQ (Zwick *et al.,* 1999; Gothwal *et al.,* 2009).

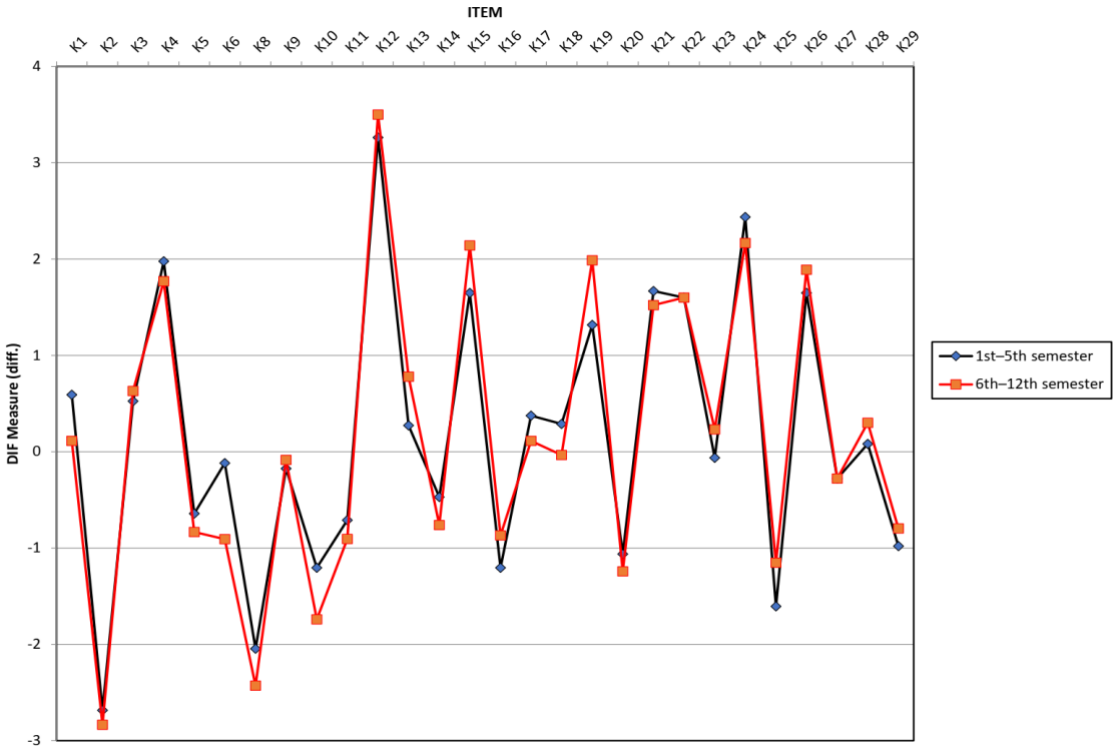


Figure 3: DIF based on the term

Discussion

This study is the first to develop AKAQ using the Rasch measurement model as a psychometric analysis. Rasch analysis is different from item response theory, which is a scale characterised by a positive correlation between the ability of respondents and the probability of respondents favouring more challenging items (Streiner & Norman, 2008). Rasch measurement can solve several problems in assessing misconceptions that cannot be resolved based on classical test theory, such as detecting the difficulty level of an item accurately and precisely, determining the misfit of items and persons, and identifying DIF items (Boone *et al.,* 2014; Adams *et al.,* 2020).

Linacre (Linacre, 1998; Linacre, 2021) established ideal ranges for infit and outfit MNSQ and ZSTD scores to minimise the inclusion of misfitting items (questions) and persons. AKAQ was analysed using Rasch analysis, and the results show that these questionnaires have a good model fit for the 28 items and 447 persons in the final tool based on MNSQ and ZSTD scores. However, this study revealed 56 persons with misfit MNSQ values (Appendix B) but positive point measure correlations (PTMEA Corr). Examination of the PTMEA Corr detects polarity items intended to examine whether or not the items in AKAQ measure the same dimension. A zero or negative value indicates a conflict with the variable or construct for the item response or respondent (Linacre, 2021). Items with positive PTMEA (+) values show that the item measuring the construct can distinguish between the ability of the respondents (Bond *et al.,* 2020). However, the persons with misfit values were excluded because those do not bring efficiency to building measurements of the questionnaire (Linacre, 1998; Wright & Stone, 1998).

Identifying and excluding misfitting items and persons in the AKAQ were crucial steps in refining the questionnaire. Linacre (Linacre, 1998; Linacre, 2021) established ideal ranges for infit and outfit MNSQ and ZSTD scores to minimise the inclusion of misfitting items (questions) and persons.

The decision to exclude specific items was based on rigorous analysis, considering both statistical indicators and practical implications. One item misfit (K7) was found based on outfit MNSQ value. K7 item (amoxicillin is an antibiotic) had the lowest difficulty level (Appendix F), yielding a 99.0% percentage of correct answers. Therefore, it was excluded due to its consistently high correct response rates, indicating a lack of variability among respondents. Retaining such items would compromise the measurement of antibiotic knowledge, as they fail to effectively differentiate between respondents with varying knowledge levels. The rationale underlying the removal

of specific items was guided by the principles of measurement efficiency and construct validity. Items with misfitting values were considered inefficient in enhancing AKAQ's accuracy. The goal was to ensure that the remaining items collectively formed a questionnaire with optimal fit validity and internal consistency, meeting psychometric standards. After exclusion, the AKAQ demonstrated improved utility, providing a more robust and efficient assessment of antibiotic knowledge. Reliability test results indicated that the questionnaire had acceptable to high internal consistency, as set by the National Quality Forum's Measure Evaluation Criteria (National Quality Forum, 2021).

The AKAQ is expected to achieve the unidimensionality criteria. The unidimensionality result confirms that all items in AKAQ measure one-dimensional antibiotic knowledge, including general knowledge of antibiotics, AMR and AMS. All unidimensionality parameters confirming the construct validity of the AKAQ achieved an acceptable threshold (Linacre, 1998; Brentani & Silvia, 2007; Linacre, 2021).

The item-person analysis indicates that all items could measure student abilities in antibiotic-related knowledge, spanning from low to high proficiency. The construction of the items, from the easiest at the bottom to the hardest at the top of the Wright map, enables a proper evaluation to capture the range of student abilities (Linacre, 1998; Linacre, 2021). The item about the ability of beta-lactamase enzyme to destroy the beta-lactam ring was the most challenging item to answer by pharmacy students, and similar findings have been reported in previous studies from the United Kingdom (Inácio *et al.,* 2017) and Pakistan (Hayat *et al.,* 2021). The question related to the mechanism of antibiotic resistance was difficult for pharmacy students to adequately answer, probably because of the inadequate education in the pharmacy curriculum, especially for students in the first part of the curriculum (first to fifth terms) than in the second part of the curriculum (sixth to twelfth terms). The least complicated item in the AKAQ (after excluding K7) was the statement about whether bacterial infections could be cured with antibiotics (K2). This finding is supported by previous studies from the United Kingdom (Inácio *et al.,* 2017) and Sri Lanka (Zawahir *et al.,* 2017), where the item related to the efficacy of antibiotics in treating bacterial infection was also correctly answered by more than 95% of the sample.

Furthermore, the DIF analysis revealed that only two of the 28 items were biased based on terms (Appendix F). DIF items were found only in K6 and K19 because these items are easier for students in the sixth to twelfth terms compared to those in the first to fifth terms. No other DIF items could explain the difference between pre-final and final-year students. The results from China (Huang *et al.,* 2013) support these findings that pre-final year students had more knowledge than students in early-year terms, likely due to their updated knowledge of pharmacology (including antibiotic courses), which they have completed in the past year. However, these items were still retained to analyse the psychometric properties of the developed test because all questionnaire items were valid and reliable.

The application of Rasch analysis in developing the AKAQ holds multifaceted significance for antibiotic knowledge assessment. Rasch analysis elevates the precision of knowledge measurement by identifying and excluding misfitting items and respondents through meticulous examination of MNSQ and ZSTD values. The fit values of MNSQ and ZSTD verify that the questionnaire achieves the validity criteria, indicating that AKAQ items measure antibiotic knowledge as a target construct appropriately based on Rasch parameters. Therefore, confirming MNSQ and ZSTD values means ensuring the effectiveness and precision of the AKAQ questionnaire.

The rigorous validation process, guided by Linacre's criteria, yields a questionnaire with strong fit validity and high internal consistency, meeting the Measure Evaluation Criteria of the National Quality Forum (NQF), establishing the AKAQ as a psychometrically robust tool for assessing antibiotic knowledge. Confirmation of unidimensionality criteria validates that all items measure a single dimension, i.e. antibiotic knowledge, strengthening questionnaire construct validity.

The present study demonstrates AKAQ's efficacy in measuring students' abilities across a spectrum of antibiotic-related knowledge, providing a comprehensive evaluation from fundamental concepts to more specific knowledge items. Beyond methodological contributions, the Rasch-validated AKAQ holds practical implications globally, allowing educators to customise pharmacy school curricula, ensuring the instrument is relevant and impactful in enhancing antibiotic knowledge education.

Limitations

This study has some limitations. First, pharmacy education in Indonesia is diverse, with no standardised curricula, inducing potential bias that may influence the external validity of results. Moreover, the AKAQ included items covering basic antibiotic knowledge, aligning with the intention to assess a broad spectrum of knowledge applicable to students in the first part of their curriculum. Therefore, while this study provides valuable insights into antibiotic knowledge among

Indonesian undergraduate pharmacy students, caution should be exercised when extrapolating the findings to different educational contexts. Data were self-reported by participants who were voluntarily recruited via WhatsApp, introducing the possibility of selection bias. Additionally, the dominance of students from some universities in the sample may impact the study's external validity. Social media recruitment channels such as WhatsApp might attract specific demographics, potentially influencing the level of antibiotic knowledge reported. Further studies are recommended to validate the questionnaire among global student populations and different educational levels. Additionally, the study only performed a DIF analysis to understand the difference based on terms; thus, further DIF analysis would be warranted to compare gender differences.

Conclusion

The AKAQ was successfully developed and validated to assess knowledge about antibiotics in undergraduate pharmacy students in Indonesia. The AKAQ achieved adequate fit validity and reliability criteria using the Rasch analysis, affirming its psychometric robustness. Rasch analysis provides a valuable tool for evaluating AKAQ's psychometric aspect and adds to existing methods. The instrument shows promise in facilitating targeted educational interventions and advancing antibiotic stewardship initiatives. Further research is required to determine the instrument's applicability across diverse pharmacy students worldwide and educational levels.

List of abbreviations

AKAQ: antibiotic knowledge assessment questionnaire
MNSQ: mean-square
ZSTD: z-standard
DIF: differential item functioning
AMR: antimicrobial resistance
CVI: content validity index
UA: universal agreement
AMS: antimicrobial stewardship
JMLE: joint maximum likelihood estimation
IRT: item response theory
CTT: classical test theory
PTMEA Corr: positive point measure correlations
K: knowledge item

Conflict of interest

The authors declare no conflict of interest.

Authors' Contributions

IYK, and MAB; methodology, formal analysis, software: IYK, MAB, and SS; ethics and data collection: DAN and RP, investigation: IYK, MAB, MM and RB; data curation and validation: MM and RB; writing—original draft preparation: IYK, MAB, MM and RB; writing—review and editing: MM, RB, DC; and funding acquisition: DC. All authors have read and approved the final version of the manuscript.

Source of funding

This work has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development, and Innovation Fund, financed supported by ITM NKFIA TKP2021-EGA-32. Ria Benko was supported by the János Bólyai research scholarship of the Hungarian Academy of Sciences.

Acknowledgement

The authors would like to thanks to APTFI (Asosiasi Perguruan Tinggi Farmasi Indonesia) and IAI (Ikatan Apoteker Indonesia).

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Appendix A: Content Validity Index (CVI) of the 29-items draft AKAQ from 4 experts

Variable construct	Panel 1		Panel 2		Panel 3		Panel 4		Expert in agreements	I-CVI Score	S-CVI score
	n	Code	n	Code	n	Code	n	Code			
K1	4	1	4	1	4	1	4	1	4	1.00	1
K2	4	1	4	1	4	1	3	1	4	1.00	1
K3	4	1	4	1	4	1	3	1	4	1.00	1
K4	4	1	4	1	4	1	4	1	4	1.00	1
K5	4	1	3	1	4	1	4	1	4	1.00	1
K6	4	1	4	1	4	1	4	1	4	1.00	1
K7	4	1	4	1	4	1	4	1	4	1.00	1
K8	4	1	4	1	4	1	4	1	4	1.00	1
K9	3	1	4	1	4	1	3	1	4	1.00	1
K10	4	1	4	1	4	1	3	1	4	1.00	1
K11	4	1	4	1	4	1	4	1	4	1.00	1
K12	3	1	3	1	4	1	4	1	4	1.00	1
K13	4	1	4	1	4	1	3	1	4	1.00	1
K14	4	1	4	1	4	1	3	1	4	1.00	1
K15	4	1	4	1	4	1	4	1	4	1.00	1
K16	4	1	4	1	4	1	4	1	4	1.00	1
K17	4	1	4	1	4	1	3	1	4	1.00	1
K18	4	1	4	1	4	1	4	1	4	1.00	1
K19	4	1	4	1	4	1	4	1	4	1.00	1
K20	4	1	3	1	4	1	4	1	4	1.00	1
K21	4	1	4	1	4	1	4	1	4	1.00	1
K22	4	1	4	1	4	1	4	1	4	1.00	1
K23	4	1	4	1	4	1	4	1	4	1.00	1
K24	4	1	4	1	4	1	4	1	4	1.00	1
K25	4	1	4	1	4	1	4	1	4	1.00	1
K26	4	1	4	1	4	1	4	1	4	1.00	1
K27	3	1	4	1	4	1	4	1	4	1.00	1
K28	4	1	4	1	4	1	4	1	4	1.00	1
K29	4	1	4	1	4	1	4	1	4	1.00	1
Mean			1.00		1.00		1.00	1.00	Summary	30.00	30.00
Average proportion of items judged as relevance (4 experts): 1.00									Average	1.00	1.00
									Conclusion	Acceptable	Acceptable

*I-CVI, item level content validity index; S-CVI, scale level content validity index

Appendix B: All items of AKAQ and percentage of answers by category response

Item	Questions	Correct answer
GENERAL KNOWLEDGE OF ANTIBIOTICS		
K1	Antibiotics are useful for viral infections	41.2%
K2	Bacterial infections can be treated with antibiotics	95.6%
K3	Antibiotics can be used to cure colds	45.0%
K4	Pain and inflammation can be treated with antibiotics	71.8%
K5	Antibiotics can cause allergic reactions	78.8%
K6	Aspirin is an antibiotic	26.0%
K7	Amoxicillin is an antibiotics	99.0%
K8	Antibiotics must be obtained with a doctor's prescription	93.0%
K9	All antibiotics must be taken before eating	30.8%
ANTIBIOTICS RESISTANCE		
K10	Resistance occurs when bacteria lose its sensitivity to antibiotics	87.0%
K11	Bacteria can alter membrane permeability and cause resistance	79.6%
K12	Beta-lactamases are enzymes produced by bacteria that break open the beta-lactam ring	9.2%
K13	Prescribing broad-spectrum antibiotics increases antibiotics resistance	56.6%
K14	Independent use of antibiotics can increase antibiotic resistance	76.8%
K15	The use of narrow-spectrum antibiotics is more at risk of causing resistance than broad-spectrum antibiotics	71.6%
K16	Sensitivity tests and bacterial culture tests are able to minimize resistance and determine the appropriate antibiotic	83.4%
K17	Antibiotics can be used independently if you have already used the same antibiotic	38.6%
K18	Antibiotics can be used by other people with the same symptoms	36.4%
K19	Bacteria that are resistant to antibiotics can be passed from one person to another	33.2%
ANTIBIOTIC STEWARDSHIP		
K20	Antibiotic stewardships an effort to optimize the use of antibiotics in patients	84.2%
K21	Antibiotics are overused Nationally and Internationally in healthcare	33.4%
K22	The sale of narrow-spectrum antibiotics without a prescription is a form of antibiotic stewardship	66.6%
K23	Rapid diagnostic tests enable more accurate diagnosis, specific antibiotic treatment and decrease antibiotic resistance	65.4%
K24	The use of combinations of antibiotics with the same spectrum reduces resistance	78.8%
K25	The study of the consumption of antibiotics and the manufacture of formularies is a preventive measure against the occurrence of antibiotic resistance	87.2%
K26	Stopping the use of antibiotics for livestock does not prevent antibiotic resistance	69.6%
K27	Antibiotic stewardship will reduce antibiotic resistance	71.8%
K28	Antibiotic stewardship improve cost-effectiveness in the health care sector	63.2%
K29	Antibiotic stewardship improve collaboration between health care providers	81.4%

*K, knowledge item

Appendix C: Person fit measurement

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
1	29	12	1,1624	0,8712	2,7278	2,8027	0,3753	0,445
2	29	17	1,4523	1,9415	1,8227	1,4418	0,2737	0,4946
3	29	18	1,0393	0,251	1,8149	1,3418	0,4547	0,4128
4	29	24	1,1135	0,4511	1,8034	1,0518	0,3282	0,3481
5	29	16	1,2479	1,2012	1,7456	1,4217	0,3689	0,4629
6	29	14	1,543	2,4915	1,7004	1,4517	0,2481	0,5182
7	29	12	1,2671	1,3513	1,692	1,4317	0,3584	0,4646
8	29	25	1,1418	0,5011	1,6544	0,8917	0,2757	0,3268
9	29	17	1,4722	2,0115	1,6504	1,2117	0,2835	0,498
10	29	22	1,6393	2,1016	1,65	0,9717	0,1708	0,4673
11	29	13	1,3457	1,7013	1,6398	1,3616	0,3281	0,4824
12	29	22	1,5429	1,8315	1,6281	0,9516	0,1995	0,4533
13	29	22	1,5538	1,8616	1,626	0,9516	0,2023	0,455
14	29	15	1,0358	0,251	1,6103	1,2716	0,4762	0,424
15	29	16	1,1341	0,7011	1,6077	1,2216	0,4265	0,4412
16	29	14	1,5252	2,4215	1,6063	1,3016	0,2709	0,5152
17	29	14	1,4106	1,9614	1,5843	1,2616	0,3108	0,4954
18	29	13	1,4157	2,0014	1,5837	1,2716	0,3153	0,4948
19	29	16	1,1914	0,9512	1,5827	1,1816	0,4116	0,4523
20	29	19	1,2266	0,9912	1,5798	0,9916	0,3578	0,4404
21	29	20	1,0424	0,251	1,5744	0,9316	0,452	0,397
22	29	11	1,4055	1,8914	1,5722	1,1916	0,3123	0,4831
23	29	15	1,2182	1,1012	1,5689	1,2116	0,395	0,4598
24	29	16	1,1371	0,7111	1,563	1,1516	0,4321	0,4418
25	29	24	1,5351	1,5715	1,5527	0,8416	0,1725	0,4087
26	29	19	1,4203	1,6814	1,5526	0,9616	0,297	0,474
27	29	20	1,2624	1,0813	1,5449	0,9015	0,341	0,4368
28	29	17	0,969	-0,079	1,542	1,0615	0,5029	0,404
29	29	20	1,6898	2,4417	1,5395	0,8915	0,1915	0,5054
30	29	24	1,1369	0,5211	1,5253	0,8215	0,3235	0,3517
31	29	20	0,9288	-0,2191	1,5247	0,8815	0,4948	0,3747
32	29	20	1,3748	1,4714	1,5121	0,8615	0,3066	0,4559
33	29	15	1,5221	2,3615	1,5058	1,1115	0,2764	0,514
34	29	20	1,3813	1,4914	1,4905	0,8415	0,3095	0,4569
35	29	15	1,1392	0,7411	1,4839	1,0715	0,4332	0,4447
36	29	18	1,3968	1,6714	1,4797	0,9215	0,3146	0,4785
37	29	18	1,1566	0,7512	1,4763	0,9215	0,417	0,4354
38	29	19	1,4258	1,7014	1,4664	0,8615	0,3025	0,4749
39	29	15	1,1638	0,8612	1,4663	1,0415	0,4279	0,4494
40	29	17	0,8645	-0,5991	1,4597	0,9415	0,5498	0,3816
41	29	24	1,3884	1,2014	1,4453	0,7414	0,2398	0,3887
42	29	17	1,4689	2,0015	1,4428	0,9214	0,2999	0,4974
43	29	17	1,0952	0,5111	1,4334	0,9014	0,4422	0,4295
44	29	18	1,2514	1,1213	1,4311	0,8614	0,3803	0,4529
45	29	4	1,359	0,9114	1,4256	0,7114	0,2872	0,3405
46	29	22	1,1725	0,7012	1,4188	0,7414	0,3596	0,3952
47	29	9	1,3643	1,5414	1,4164	0,8514	0,3405	0,4557
48	29	19	1,2876	1,2113	1,4141	0,7914	0,3551	0,4513
49	29	12	1,2021	1,0512	1,4123	0,9614	0,4053	0,4525
50	29	18	1,1987	0,9212	1,4098	0,8314	0,4014	0,4433
51	29	15	1,5007	2,2715	1,4085	0,9414	0,2986	0,5103
52	29	17	1,3907	1,7114	1,3994	0,8514	0,3325	0,484
53	29	22	1,377	1,3514	1,3988	0,7214	0,2831	0,4283
54	29	19	0,9688	-0,059	1,3929	0,7614	0,4954	0,3914
55	29	22	1,1292	0,5511	1,3863	0,7114	0,3886	0,3878
56	29	19	1,4001	1,6114	1,3857	0,7514	0,3182	0,4706
57	29	13	1,2687	1,3713	1,3797	0,9214	0,3901	0,4684
58	29	17	1,072	0,4011	1,3796	0,8214	0,4643	0,4249
59	29	13	1,2692	1,3713	1,371	0,9014	0,3864	0,4685
60	29	22	1,2977	1,1113	1,3697	0,6914	0,3162	0,4158
61	29	17	1,4635	1,9815	1,3684	0,8014	0,3107	0,4965

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
62	29	8	0,91	-0,2991	1,3679	0,7414	0,515	0,3602
63	29	17	1,4694	2,0015	1,3664	0,8014	0,3094	0,4975
64	29	21	1,2612	1,0413	1,3636	0,6814	0,3566	0,4245
65	29	15	1,2605	1,2913	1,3631	0,8614	0,3918	0,4677
66	29	18	1,3788	1,6014	1,3555	0,7514	0,335	0,4754
67	29	20	1,2476	1,0312	1,3533	0,6914	0,365	0,4343
68	29	19	1,2335	1,0112	1,351	0,7114	0,3831	0,4417
69	29	18	1,3851	1,6214	1,3494	0,7413	0,335	0,4765
70	29	16	1,4068	1,8414	1,3464	0,8013	0,3364	0,4914
71	29	18	1,438	1,8114	1,3239	0,7013	0,32	0,4855
72	29	18	1,438	1,8114	1,3239	0,7013	0,32	0,4855
73	29	17	1,076	0,4211	1,3207	0,7313	0,4647	0,4257
74	29	24	1,1517	0,5612	1,3144	0,6213	0,3308	0,354
75	29	11	1,1285	0,6911	1,313	0,7613	0,4422	0,4329
76	29	19	1,1367	0,6411	1,3126	0,6613	0,4192	0,424
77	29	15	1,0503	0,3211	1,3121	0,7713	0,4886	0,4269
78	29	19	1,0877	0,4411	1,3061	0,6513	0,4428	0,4148
79	29	19	1,3417	1,4113	1,3057	0,6513	0,3533	0,4607
80	29	19	1,3197	1,3313	1,2997	0,6413	0,3561	0,4569
81	29	11	1,1611	0,8412	1,2932	0,7313	0,4316	0,4391
82	29	21	1,3533	1,3414	1,2915	0,6013	0,3231	0,4397
83	29	18	1,3328	1,4313	1,2883	0,6513	0,3631	0,4674
84	29	21	1,3412	1,3013	1,2878	0,6013	0,3271	0,4378
85	29	19	1,1957	0,8712	1,284	0,6213	0,4061	0,4349
86	29	23	0,8479	-0,4592	1,2821	0,5913	0,487	0,3216
87	29	24	1,0884	0,3811	1,2812	0,5913	0,3548	0,3442
88	29	24	1,2333	0,7912	1,279	0,5813	0,31	0,3663
89	29	19	1,2366	1,0312	1,2676	0,6013	0,392	0,4422
90	29	21	1,1357	0,6011	1,2675	0,5813	0,4097	0,4028
91	29	19	1,2998	1,2613	1,2617	0,5913	0,3685	0,4534
92	29	11	1,3178	1,5313	1,2601	0,6713	0,3788	0,4678
93	29	21	1,2091	0,8612	1,2591	0,5713	0,3766	0,4156
94	29	15	0,9601	-0,139	1,2585	0,6713	0,5266	0,4082
95	29	15	1,1858	0,9612	1,2578	0,6713	0,4318	0,4537
96	29	20	1,1304	0,6011	1,2574	0,5713	0,4222	0,4134
97	29	16	1,3395	1,5713	1,2565	0,6513	0,372	0,4795
98	29	20	1,0895	0,4411	1,2542	0,5713	0,4307	0,4058
99	29	11	1,1715	0,8912	1,2528	0,6513	0,4304	0,4411
100	29	14	1,3018	1,5013	1,2516	0,6713	0,3897	0,476
101	29	18	0,9673	-0,079	1,2514	0,6013	0,5132	0,3982
102	29	22	0,98	0,011	1,242	0,5512	0,4564	0,3613
103	29	21	1,3462	1,3213	1,2413	0,5512	0,3285	0,4386
104	29	20	1,201	0,8612	1,2407	0,5512	0,3951	0,4261
105	29	9	1,1374	0,6711	1,2396	0,5912	0,44	0,4161
106	29	19	1,22	0,9612	1,2367	0,5612	0,3992	0,4393
107	29	18	1,1066	0,5411	1,2303	0,5712	0,4582	0,4259
108	29	16	1,329	1,5313	1,2257	0,5912	0,3805	0,4777
109	29	12	1,0633	0,3911	1,225	0,6212	0,4891	0,4256
110	29	23	1,2299	0,8412	1,2216	0,5312	0,336	0,3873
111	29	16	1,3179	1,4913	1,2143	0,5712	0,3853	0,4757
112	29	20	0,9983	0,071	1,2121	0,5212	0,4738	0,3885
113	29	19	1,0835	0,4311	1,2111	0,5212	0,4521	0,414
114	29	16	1,0983	0,5411	1,2025	0,5512	0,4716	0,4342
115	29	19	1,2424	1,0512	1,2019	0,5112	0,3966	0,4433
116	29	17	1,0198	0,161	1,1955	0,5312	0,5014	0,4145
117	29	10	1,3517	1,6014	1,1933	0,5312	0,3667	0,4651
118	29	7	1,0607	0,3111	1,1878	0,4912	0,4566	0,3729
119	29	17	1,1952	0,9412	1,1878	0,5112	0,4282	0,4487
120	29	17	1,1952	0,9412	1,1878	0,5112	0,4282	0,4487
121	29	17	1,1952	0,9412	1,1878	0,5112	0,4282	0,4487
122	29	13	1,1819	0,9712	1,1835	0,5412	0,4405	0,4521
123	29	16	1,2614	1,2513	1,1804	0,5112	0,4097	0,4654
124	29	13	1,274	1,3913	1,1797	0,5312	0,4108	0,4694

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
125	29	15	1,1525	0,8012	1,1791	0,5212	0,4526	0,4473
126	29	11	1,0123	0,131	1,1774	0,5112	0,4977	0,41
127	29	9	1,0604	0,3411	1,1733	0,4812	0,4748	0,4018
128	29	17	1,2328	1,0912	1,173	0,4912	0,4165	0,4557
129	29	13	0,9992	0,061	1,1609	0,4912	0,5124	0,4157
130	29	13	1,149	0,8111	1,1581	0,4912	0,4547	0,4458
131	29	16	1,2723	1,3013	1,1565	0,4712	0,4092	0,4674
132	29	14	1,0915	0,5311	1,1553	0,4812	0,4761	0,4358
133	29	11	1,091	0,5111	1,1535	0,4712	0,4765	0,4256
134	29	23	1,0127	0,141	1,1514	0,4512	0,4295	0,3514
135	29	22	0,9946	0,071	1,1507	0,4412	0,4517	0,364
136	29	11	1,1629	0,8512	1,1505	0,4612	0,4458	0,4394
137	29	20	0,8512	-0,5691	1,1443	0,4311	0,5332	0,3587
138	29	22	1,255	0,9713	1,1432	0,4311	0,3519	0,4089
139	29	22	1,255	0,9713	1,1432	0,4311	0,3519	0,4089
140	29	16	1,2217	1,0812	1,1396	0,4411	0,4284	0,458
141	29	16	1,2268	1,1112	1,1393	0,4411	0,4278	0,4589
142	29	11	1,1466	0,7811	1,1388	0,4411	0,4529	0,4363
143	29	20	1,0816	0,4111	1,1343	0,4211	0,456	0,4044
144	29	20	1,2798	1,1413	1,1318	0,4111	0,3812	0,4398
145	29	19	1,1373	0,6411	1,1276	0,4011	0,4461	0,4241
146	29	12	1,0608	0,3711	1,1237	0,4111	0,4883	0,4251
147	29	22	1,101	0,4511	1,1217	0,4111	0,4131	0,383
148	29	19	1,2384	1,0312	1,1176	0,3911	0,4104	0,4426
149	29	13	1,134	0,7411	1,1104	0,3911	0,4656	0,4429
150	29	14	1,2101	1,0912	1,1086	0,3811	0,4417	0,4589
151	29	21	1,1472	0,6411	1,1033	0,3911	0,4128	0,4049
152	29	19	1,1715	0,7812	1,1027	0,3711	0,4333	0,4304
153	29	18	1,2451	1,1012	1,1008	0,3611	0,4161	0,4518
154	29	20	1,2438	1,0112	1,096	0,3711	0,3998	0,4336
155	29	16	1,1403	0,7311	1,0927	0,3511	0,4631	0,4425
156	29	18	1,1204	0,6011	1,0917	0,3511	0,4593	0,4286
157	29	13	1,2136	1,1212	1,0892	0,3411	0,4409	0,4582
158	29	15	1,18	0,9312	1,0874	0,3411	0,4529	0,4526
159	29	20	1,1284	0,5911	1,076	0,3411	0,4423	0,413
160	29	13	1,1441	0,7911	1,0757	0,3111	0,4694	0,4448
161	29	19	1,0179	0,151	1,0734	0,3211	0,4923	0,4012
162	29	18	1,035	0,231	1,0733	0,3211	0,4937	0,4119
163	29	22	1,3596	1,3014	1,0722	0,3511	0,3292	0,4256
164	29	20	0,9934	0,051	1,0688	0,3311	0,4876	0,3875
165	29	20	1,2746	1,1213	1,0682	0,3311	0,3927	0,439
166	29	16	1,2089	1,0312	1,0624	0,2911	0,4442	0,4556
167	29	23	1,1815	0,6912	1,061	0,3411	0,3704	0,3796
168	29	22	1,2411	0,9312	1,0561	0,3311	0,3722	0,4066
169	29	16	1,0727	0,4211	1,0553	0,2711	0,4927	0,4291
170	29	14	1,0934	0,5411	1,0498	0,261	0,4898	0,4362
171	29	18	1,0445	0,271	1,0461	0,271	0,4935	0,4138
172	29	24	1,0906	0,3811	1,0403	0,331	0,374	0,3445
173	29	15	0,9863	0,001	1,0379	0,231	0,5309	0,4137
174	29	18	1,1639	0,7812	1,0316	0,251	0,4545	0,4368
175	29	21	1,0784	0,3911	1,0309	0,291	0,4472	0,3925
176	29	16	1,1678	0,8512	1,0291	0,221	0,4629	0,4478
177	29	21	1,1094	0,5011	1,0289	0,291	0,4369	0,3981
178	29	14	1,0775	0,4611	1,0239	0,201	0,5003	0,433
179	29	16	1,1453	0,7511	1,022	0,211	0,4715	0,4434
180	29	21	1,0469	0,271	1,0201	0,281	0,4604	0,3868
181	29	15	1,1155	0,6311	1,0199	0,201	0,4839	0,44
182	29	21	1,1235	0,5511	1,0191	0,281	0,4338	0,4007
183	29	20	1,0495	0,281	1,0167	0,261	0,4765	0,3983
184	29	14	1,1516	0,8212	1,0149	0,181	0,4734	0,4477
185	29	16	1,076	0,4311	1,0146	0,191	0,4952	0,4298
186	29	25	1,2328	0,7212	1,0143	0,341	0,3071	0,3396
187	29	18	0,8765	-0,5091	1,0136	0,211	0,5662	0,379

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
188	29	15	1,0674	0,4011	1,0089	0,171	0,5019	0,4304
189	29	19	0,8836	-0,4491	1,0084	0,221	0,5469	0,3738
190	29	16	1,1024	0,5511	1,0046	0,171	0,4893	0,435
191	29	8	1,3483	1,3713	1,0032	0,211	0,384	0,4385
192	29	24	0,8646	-0,3491	1,0015	0,291	0,466	0,3067
193	29	17	1,0745	0,4111	1,0013	0,181	0,4939	0,4254
194	29	17	1,0828	0,4511	1,0011	0,181	0,4929	0,4271
195	29	16	1,0912	0,5011	1,0008	0,161	0,4933	0,4328
196	29	19	1,1555	0,7212	0,9957	0,201	0,4526	0,4275
197	29	18	1,1157	0,5811	0,9957	0,181	0,4743	0,4277
198	29	19	1,0531	0,3011	0,9956	0,201	0,4876	0,4081
199	29	23	1,0157	0,151	0,9929	0,251	0,4397	0,3519
200	29	9	0,8609	-0,5791	0,9901	0,171	0,5679	0,362
201	29	17	1,0778	0,4311	0,9899	0,161	0,4963	0,4261
202	29	17	1,0597	0,3511	0,986	0,151	0,5024	0,4225
203	29	17	1,1155	0,5911	0,9856	0,151	0,4821	0,4335
204	29	21	1,151	0,6512	0,9844	0,231	0,4284	0,4055
205	29	14	1,0643	0,3911	0,984	0,111	0,5074	0,4304
206	29	19	1,2222	0,9712	0,9786	0,181	0,4341	0,4397
207	29	16	1,0284	0,211	0,9717	0,101	0,52	0,4202
208	29	21	0,8948	-0,3491	0,97	0,211	0,522	0,3576
209	29	17	1,0534	0,3211	0,9677	0,111	0,5075	0,4212
210	29	21	1,0754	0,3711	0,9674	0,211	0,4554	0,392
211	29	14	1,0895	0,5211	0,9632	0,061	0,5018	0,4354
212	29	20	1,0303	0,201	0,9626	0,181	0,4904	0,3946
213	29	15	0,8633	-0,6591	0,9575	0,061	0,5838	0,3871
214	29	18	1,0693	0,3811	0,9527	0,111	0,4958	0,4187
215	29	19	1,1079	0,5311	0,9509	0,131	0,4749	0,4186
216	29	20	1,1564	0,6912	0,9509	0,171	0,4494	0,4181
217	29	16	1,0919	0,5111	0,9503	0,061	0,5001	0,433
218	29	23	0,9458	-0,0991	0,9463	0,1909	0,4596	0,3396
219	29	19	1,0156	0,141	0,9452	0,1209	0,5064	0,4008
220	29	17	0,9622	-0,109	0,9443	0,0709	0,541	0,4026
221	29	16	1,0109	0,121	0,9384	0,0309	0,5291	0,4166
222	29	18	1,0919	0,4811	0,9333	0,0709	0,4912	0,4231
223	29	22	1,1486	0,6211	0,9309	0,1609	0,4173	0,3912
224	29	25	1,1033	0,4011	0,9292	0,2509	0,3411	0,3212
225	29	19	1,1104	0,5411	0,9263	0,0909	0,4782	0,4191
226	29	18	1,0612	0,3411	0,9255	0,0609	0,5025	0,4171
227	29	18	0,9623	-0,099	0,9243	0,0609	0,5351	0,3972
228	29	24	1,1141	0,4511	0,9232	0,1909	0,3788	0,3482
229	29	17	1,0822	0,4511	0,9225	0,0209	0,5025	0,427
230	29	15	1,0216	0,171	0,9218	-0,0191	0,5298	0,4211
231	29	23	0,9426	-0,1091	0,9209	0,1609	0,4701	0,339
232	29	21	1,1059	0,4911	0,9193	0,1509	0,4536	0,3975
233	29	15	1,0275	0,201	0,9189	-0,0291	0,5292	0,4223
234	29	18	1,0619	0,3511	0,9187	0,0509	0,503	0,4172
235	29	24	1,2493	0,8412	0,9173	0,1809	0,3356	0,3687
236	29	21	1,0099	0,121	0,9075	0,1309	0,4874	0,3799
237	29	13	1,0012	0,071	0,9059	-0,0691	0,5391	0,4161
238	29	17	1,0356	0,241	0,9036	-0,0191	0,5216	0,4177
239	29	14	0,9941	0,031	0,9014	-0,0791	0,5437	0,4159
240	29	22	1,1531	0,6312	0,9007	0,1209	0,4207	0,3919
241	29	14	1,0484	0,311	0,8992	-0,0891	0,5254	0,4271
242	29	11	0,915	-0,3791	0,8985	-0,0691	0,5663	0,3898
243	29	15	1,0751	0,4411	0,8958	-0,0791	0,5167	0,432
244	29	13	0,9673	-0,109	0,8921	-0,1091	0,5542	0,409
245	29	22	1,0084	0,121	0,8894	0,1009	0,474	0,3665
246	29	18	0,993	0,041	0,8892	-0,0091	0,5318	0,4035
247	29	16	0,956	-0,149	0,8876	-0,0791	0,5546	0,4051
248	29	20	1,0852	0,4211	0,8863	0,0709	0,4792	0,405
249	29	17	1,0282	0,201	0,8834	-0,0591	0,5262	0,4162
250	29	20	0,9744	-0,029	0,883	0,0609	0,5159	0,3838

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
251	29	22	0,885	-0,3591	0,8827	0,0909	0,5181	0,3434
252	29	19	1,0185	0,161	0,8798	0,0109	0,5138	0,4013
253	29	21	1,0713	0,3611	0,8794	0,0909	0,4705	0,3912
254	29	17	0,9811	-0,019	0,8696	-0,0891	0,5444	0,4065
255	29	16	0,9688	-0,089	0,8656	-0,1291	0,553	0,4078
256	29	23	0,9287	-0,1591	0,8651	0,0809	0,4854	0,3365
257	29	15	0,9411	-0,2391	0,8615	-0,1591	0,5652	0,4042
258	29	16	0,9417	-0,2191	0,8591	-0,1391	0,5638	0,4021
259	29	11	1,1298	0,7011	0,8585	-0,1591	0,4964	0,4331
260	29	19	0,9756	-0,029	0,8539	-0,0291	0,5329	0,3928
261	29	16	0,9076	-0,3991	0,8536	-0,1491	0,5777	0,3947
262	29	15	0,8963	-0,4791	0,8497	-0,1892	0,5832	0,3944
263	29	16	0,9781	-0,039	0,8496	-0,1592	0,5527	0,4098
264	29	18	1,0304	0,211	0,8494	-0,0892	0,5242	0,411
265	29	16	0,9698	-0,079	0,849	-0,1592	0,5555	0,408
266	29	21	0,8422	-0,5692	0,8418	0,0308	0,557	0,3469
267	29	20	1,1169	0,5511	0,8402	0,0008	0,4771	0,4109
268	29	18	0,9788	-0,019	0,8399	-0,0992	0,5423	0,4006
269	29	16	0,9641	-0,109	0,8397	-0,1892	0,5587	0,4068
270	29	13	1,0557	0,3511	0,8394	-0,2392	0,5302	0,4273
271	29	21	0,9711	-0,029	0,8348	0,0208	0,5108	0,3725
272	29	21	0,9862	0,031	0,8343	0,0208	0,5029	0,3754
273	29	24	1,0635	0,3011	0,8323	0,0808	0,4053	0,3402
274	29	20	0,9351	-0,1891	0,832	-0,0192	0,5366	0,376
275	29	17	0,9137	-0,3491	0,8298	-0,1692	0,5721	0,3923
276	29	24	1,0021	0,111	0,8289	0,0708	0,4242	0,3302
277	29	2	1,4408	0,8214	0,8263	0,3408	0,2899	0,2599
278	29	19	1,1006	0,5011	0,8232	-0,0892	0,4978	0,4172
279	29	15	0,908	-0,4191	0,823	-0,2592	0,5827	0,397
280	29	22	1,0212	0,171	0,8224	0,0008	0,4736	0,3688
281	29	17	0,9598	-0,119	0,8213	-0,1892	0,5582	0,4021
282	29	26	0,9529	0,031	0,817	0,2208	0,361	0,2686
283	29	14	0,9535	-0,179	0,8164	-0,2892	0,5694	0,4073
284	29	21	0,9397	-0,1591	0,8152	0,0008	0,5236	0,3664
285	29	14	0,933	-0,2891	0,811	-0,3092	0,5766	0,4029
286	29	13	0,915	-0,3991	0,8102	-0,3092	0,5826	0,3978
287	29	17	0,9218	-0,3091	0,8094	-0,2092	0,573	0,394
288	29	13	0,9941	0,031	0,8079	-0,3192	0,5549	0,4147
289	29	22	0,9698	-0,029	0,8056	-0,0192	0,4938	0,3594
290	29	15	0,9052	-0,4291	0,8039	-0,2992	0,5859	0,3964
291	29	17	0,8586	-0,6291	0,8034	-0,2292	0,5959	0,3803
292	29	19	0,9248	-0,2591	0,8031	-0,1192	0,5572	0,3825
293	29	22	1,0505	0,2711	0,8001	-0,0292	0,4681	0,3741
294	29	21	0,8507	-0,5391	0,7991	-0,0292	0,557	0,3486
295	29	16	0,9527	-0,169	0,7968	-0,2892	0,569	0,4044
296	29	21	0,9046	-0,2991	0,7954	-0,0292	0,5374	0,3595
297	29	15	0,9201	-0,3491	0,7949	-0,3292	0,5824	0,3996
298	29	12	1,0078	0,101	0,7937	-0,3392	0,5498	0,4143
299	29	6	0,9348	-0,1091	0,7933	-0,0092	0,5212	0,3317
300	29	13	0,8774	-0,6091	0,7927	-0,3592	0,5977	0,3896
301	29	22	1,0328	0,211	0,7898	-0,0392	0,4767	0,3709
302	29	14	0,8569	-0,7191	0,7895	-0,3592	0,607	0,3861
303	29	18	0,9871	0,021	0,7892	-0,2092	0,5482	0,4023
304	29	14	0,8816	-0,5791	0,7889	-0,3592	0,5978	0,3917
305	29	16	0,9079	-0,3991	0,7827	-0,3192	0,5859	0,3948
306	29	16	0,8291	-0,8192	0,7823	-0,3192	0,6144	0,3773
307	29	19	1,0122	0,131	0,7812	-0,1592	0,5319	0,4001
308	29	19	0,9195	-0,2791	0,7769	-0,1692	0,5623	0,3813
309	29	13	0,863	-0,6891	0,7752	-0,4092	0,6049	0,3864
310	29	17	0,9076	-0,3791	0,7733	-0,2892	0,5831	0,391
311	29	19	1,0082	0,111	0,7707	-0,1792	0,5348	0,3993
312	29	18	0,9331	-0,2291	0,7669	-0,2492	0,5684	0,3911
313	29	22	1,0463	0,261	0,7631	-0,0892	0,4752	0,3733

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
314	29	17	0,7922	-0,9792	0,7593	-0,3292	0,6244	0,3653
315	29	13	0,8387	-0,8392	0,7578	-0,4492	0,6154	0,3809
316	29	17	0,8785	-0,5291	0,7569	-0,3292	0,5948	0,3847
317	29	17	0,9148	-0,3391	0,7552	-0,3392	0,5835	0,3925
318	29	11	0,9732	-0,069	0,7551	-0,4092	0,5628	0,402
319	29	23	0,8252	-0,5492	0,7548	-0,0792	0,5295	0,3172
320	29	18	0,9491	-0,1591	0,7537	-0,2792	0,5657	0,3944
321	29	25	1,1194	0,4411	0,7532	0,0408	0,3684	0,3236
322	29	16	0,8093	-0,9292	0,7516	-0,3992	0,6235	0,3727
323	29	19	0,9155	-0,2991	0,7508	-0,2192	0,567	0,3805
324	29	18	0,8898	-0,4391	0,749	-0,2893	0,5856	0,3819
325	29	18	0,8306	-0,7392	0,7477	-0,2893	0,6053	0,369
326	29	21	0,9615	-0,069	0,7468	-0,1093	0,5247	0,3707
327	29	20	0,8738	-0,4591	0,7465	-0,1593	0,5694	0,3634
328	29	16	0,8971	-0,4591	0,7462	-0,4093	0,5952	0,3924
329	29	23	1,0096	0,131	0,7451	-0,0893	0,467	0,3509
330	29	22	0,9692	-0,029	0,741	-0,1193	0,5022	0,3593
331	29	18	0,9325	-0,2391	0,7393	-0,3093	0,5733	0,391
332	29	11	0,7869	-1,0992	0,7378	-0,4593	0,6291	0,3615
333	29	17	0,8852	-0,4891	0,736	-0,3793	0,5959	0,3861
334	29	17	0,9063	-0,3791	0,7336	-0,3893	0,5895	0,3907
335	29	17	0,9063	-0,3791	0,7336	-0,3893	0,5895	0,3907
336	29	14	0,7334	-1,4693	0,7322	-0,5193	0,6577	0,3572
337	29	15	0,8995	-0,4591	0,7318	-0,4893	0,599	0,3951
338	29	13	0,9164	-0,3891	0,7272	-0,5393	0,5932	0,3981
339	29	18	0,9138	-0,3291	0,7265	-0,3393	0,5812	0,387
340	29	20	0,9667	-0,059	0,7243	-0,1993	0,5425	0,3823
341	29	24	1,0503	0,2611	0,722	-0,0793	0,4286	0,3381
342	29	16	0,848	-0,7192	0,7206	-0,4693	0,615	0,3815
343	29	21	1,0366	0,231	0,7204	-0,1493	0,506	0,3849
344	29	21	0,9396	-0,1591	0,72	-0,1493	0,5358	0,3664
345	29	12	0,8433	-0,7992	0,7199	-0,5393	0,6157	0,379
346	29	17	0,8529	-0,6591	0,7177	-0,4193	0,6092	0,379
347	29	21	0,9641	-0,059	0,7165	-0,1593	0,5284	0,3712
348	29	20	0,9531	-0,119	0,7143	-0,2093	0,5485	0,3796
349	29	4	0,9915	0,121	0,7139	0,0607	0,4812	0,2909
350	29	18	0,9068	-0,3591	0,7136	-0,3693	0,5857	0,3855
351	29	22	1,0533	0,2811	0,7136	-0,1693	0,4818	0,3746
352	29	18	0,8226	-0,7792	0,7135	-0,3693	0,6127	0,3672
353	29	18	0,8226	-0,7792	0,7135	-0,3693	0,6127	0,3672
354	29	15	0,8474	-0,7492	0,7118	-0,5393	0,6193	0,3835
355	29	22	0,7594	-0,8892	0,7076	-0,1793	0,5803	0,3181
356	29	21	0,9604	-0,069	0,7074	-0,1693	0,5312	0,3704
357	29	17	0,8572	-0,6391	0,7069	-0,4493	0,6094	0,38
358	29	23	0,9178	-0,1991	0,7066	-0,1493	0,5001	0,3345
359	29	18	0,7037	-1,4193	0,7058	-0,3793	0,6561	0,3396
360	29	21	0,8969	-0,3391	0,7051	-0,1793	0,5521	0,358
361	29	20	0,8568	-0,5391	0,7051	-0,2293	0,5806	0,3599
362	29	25	0,9126	-0,1291	0,7024	-0,0193	0,4372	0,2922
363	29	18	0,7815	-0,9892	0,702	-0,3893	0,6284	0,3579
364	29	19	0,894	-0,3991	0,701	-0,3193	0,5816	0,376
365	29	18	0,8724	-0,5291	0,6958	-0,3993	0,5993	0,3782
366	29	19	0,8805	-0,4591	0,6953	-0,3293	0,587	0,3732
367	29	17	0,8422	-0,7092	0,6881	-0,4893	0,6174	0,3766
368	29	21	0,9532	-0,099	0,6876	-0,2093	0,5363	0,3691
369	29	16	0,8255	-0,8392	0,6863	-0,5593	0,6275	0,3765
370	29	18	0,8198	-0,7892	0,6862	-0,4293	0,6174	0,3666
371	29	19	0,8844	-0,4391	0,6854	-0,3493	0,5872	0,374
372	29	19	0,8723	-0,4991	0,6853	-0,3493	0,5913	0,3714
373	29	18	0,8635	-0,5691	0,6828	-0,4293	0,6043	0,3762
374	29	18	0,8635	-0,5691	0,6828	-0,4293	0,6043	0,3762
375	29	24	0,8643	-0,3491	0,6788	-0,1393	0,4932	0,3067
376	29	15	0,8327	-0,8392	0,6774	-0,6393	0,6292	0,3802

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
377	29	19	0,7829	-0,9392	0,6763	-0,3693	0,6208	0,3519
378	29	21	0,8193	-0,6792	0,6754	-0,2293	0,5804	0,3422
379	29	16	0,8072	-0,9492	0,6726	-0,5993	0,636	0,3722
380	29	24	1,1274	0,4911	0,6659	-0,1593	0,4137	0,3503
381	29	20	0,8373	-0,6292	0,6649	-0,2993	0,5926	0,3558
382	29	15	0,8097	-0,9692	0,6648	-0,6693	0,6386	0,3749
383	29	23	0,9885	0,061	0,6641	-0,2193	0,4846	0,3472
384	29	18	0,7894	-0,9492	0,6631	-0,4793	0,6308	0,3597
385	29	18	0,7894	-0,9492	0,6631	-0,4793	0,6308	0,3597
386	29	14	0,7537	-1,3392	0,6616	-0,7193	0,6586	0,3622
387	29	24	0,8228	-0,4892	0,6572	-0,1793	0,5089	0,2992
388	29	21	0,8913	-0,3591	0,6545	-0,2593	0,5608	0,3569
389	29	18	0,7926	-0,9292	0,6534	-0,4993	0,6313	0,3605
390	29	14	0,7395	-1,4293	0,6531	-0,7393	0,6644	0,3587
391	29	19	0,8513	-0,5991	0,6505	-0,4193	0,6035	0,3669
392	29	23	0,9053	-0,2491	0,6486	-0,2494	0,5116	0,3322
393	29	16	0,8072	-0,9492	0,6423	-0,6794	0,6408	0,3723
394	29	19	0,7422	-1,1493	0,6396	-0,4394	0,6403	0,3426
395	29	20	0,8508	-0,5691	0,6394	-0,3494	0,5921	0,3586
396	29	16	0,7945	-1,0192	0,6363	-0,6994	0,6457	0,3693
397	29	20	0,8277	-0,6692	0,6349	-0,3594	0,6001	0,3537
398	29	16	0,7749	-1,1292	0,6337	-0,7094	0,6524	0,3647
399	29	16	0,7742	-1,1392	0,6323	-0,7094	0,6529	0,3646
400	29	12	0,8151	-0,9692	0,6316	-0,7994	0,6381	0,3726
401	29	18	0,7081	-1,3893	0,6307	-0,5494	0,6621	0,3407
402	29	15	0,7441	-1,3593	0,6298	-0,7794	0,6656	0,3594
403	29	20	0,8117	-0,7492	0,6294	-0,3694	0,6062	0,3503
404	29	20	0,8117	-0,7492	0,6294	-0,3694	0,6062	0,3503
405	29	16	0,7564	-1,2392	0,6291	-0,7194	0,6593	0,3604
406	29	15	0,733	-1,4293	0,6253	-0,7894	0,67	0,3567
407	29	15	0,7289	-1,4593	0,6248	-0,7894	0,6714	0,3557
408	29	20	0,8672	-0,4891	0,6241	-0,3794	0,5904	0,3621
409	29	17	0,7561	-1,1892	0,6231	-0,6594	0,6553	0,3569
410	29	16	0,7618	-1,2092	0,6216	-0,7394	0,6586	0,3616
411	29	19	0,8132	-0,7792	0,6215	-0,4794	0,6202	0,3586
412	29	21	0,8329	-0,6092	0,6213	-0,3194	0,5844	0,345
413	29	14	0,7522	-1,3492	0,6205	-0,8394	0,6646	0,3618
414	29	17	0,7884	-1,0092	0,6204	-0,6694	0,6457	0,3644
415	29	21	0,8684	-0,4591	0,6202	-0,3294	0,5739	0,3522
416	29	20	0,6852	-1,3793	0,6176	-0,3894	0,6497	0,3218
417	29	18	0,7427	-1,1993	0,6169	-0,5894	0,6529	0,3489
418	29	15	0,7783	-1,1592	0,6136	-0,8194	0,6571	0,3675
419	29	19	0,8071	-0,8092	0,6114	-0,4994	0,6239	0,3573
420	29	23	0,9247	-0,1691	0,6038	-0,3294	0,5134	0,3358
421	29	21	0,823	-0,6592	0,6004	-0,3594	0,5906	0,3429
422	29	18	0,6546	-1,7093	0,5979	-0,6294	0,6854	0,3276
423	29	16	0,7406	-1,3293	0,5973	-0,8094	0,6691	0,3566
424	29	22	0,8244	-0,6092	0,5965	-0,3694	0,57	0,3314
425	29	19	0,6072	-1,8994	0,5962	-0,5394	0,6917	0,3099
426	29	19	0,6072	-1,8994	0,5962	-0,5394	0,6917	0,3099
427	29	18	0,7392	-1,2193	0,5945	-0,6394	0,6577	0,3481
428	29	25	0,9519	-0,009	0,5944	-0,1694	0,4375	0,2984
429	29	20	0,7828	-0,8892	0,5928	-0,4394	0,6211	0,344
430	29	21	0,7873	-0,8192	0,5845	-0,3894	0,6047	0,3354
431	29	21	0,7821	-0,8492	0,5836	-0,3894	0,6064	0,3343
432	29	23	0,8528	-0,4491	0,5812	-0,3694	0,5405	0,3225
433	29	22	0,8096	-0,6692	0,5805	-0,3994	0,5775	0,3284
434	29	19	0,7334	-1,1893	0,5732	-0,5894	0,6527	0,3406
435	29	19	0,7006	-1,3693	0,5642	-0,6094	0,6645	0,3329
436	29	25	0,8878	-0,1991	0,5547	-0,2294	0,4631	0,2882
437	29	12	0,7087	-1,6293	0,5519	-1,0494	0,685	0,3474
438	29	21	0,7682	-0,9092	0,5487	-0,4595	0,6162	0,3313
439	29	20	0,7466	-1,0693	0,5455	-0,5395	0,6404	0,3359

No	COUNT	SCORE	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
440	29	23	0,7746	-0,7592	0,5421	-0,4395	0,5699	0,3073
441	29	23	0,7746	-0,7592	0,5421	-0,4395	0,5699	0,3073
442	29	18	0,6976	-1,4493	0,539	-0,7795	0,6802	0,3382
443	29	20	0,6832	-1,3893	0,539	-0,5495	0,6607	0,3214
444	29	13	0,6857	-1,7993	0,5354	-1,1295	0,6984	0,3444
445	29	19	0,6895	-1,4293	0,535	-0,6795	0,6728	0,3302
446	29	21	0,7313	-1,0893	0,5346	-0,4895	0,6296	0,3233
447	29	21	0,7596	-0,9492	0,5316	-0,4895	0,6218	0,3294
448	29	19	0,6949	-1,3993	0,5295	-0,6895	0,6722	0,3315
449	29	17	0,6453	-1,8494	0,5291	-0,9195	0,7056	0,3297
450	29	23	0,7684	-0,7892	0,5222	-0,4795	0,5747	0,3061
451	29	21	0,7283	-1,0993	0,5208	-0,5095	0,6331	0,3226
452	29	21	0,7198	-1,1393	0,5203	-0,5195	0,6356	0,3207
453	29	17	0,645	-1,8494	0,5185	-0,9495	0,7074	0,3296
454	29	21	0,7317	-1,0793	0,5156	-0,5295	0,633	0,3233
455	29	26	1,1577	0,4912	0,5149	-0,1295	0,3478	0,2961
456	29	21	0,7254	-1,1193	0,509	-0,5395	0,6361	0,3219
457	29	22	0,741	-0,9793	0,5074	-0,5395	0,6108	0,3142
458	29	22	0,7174	-1,0893	0,5045	-0,5495	0,6186	0,3091
459	29	24	0,822	-0,4992	0,5043	-0,4295	0,5294	0,2991
460	29	19	0,6591	-1,5993	0,5013	-0,7595	0,688	0,3229
461	29	21	0,7004	-1,2393	0,4996	-0,5595	0,6451	0,3164
462	29	18	0,6041	-2,0194	0,4989	-0,8895	0,7159	0,3147
463	29	22	0,7474	-0,9493	0,4985	-0,5595	0,61	0,3155
464	29	20	0,6445	-1,5994	0,4964	-0,6495	0,6796	0,3121
465	29	19	0,6499	-1,6494	0,4917	-0,7895	0,6926	0,3206
466	29	17	0,6189	-2,0194	0,4903	-1,0295	0,7203	0,3229
467	29	22	0,7076	-1,1293	0,4851	-0,5895	0,6247	0,307
468	29	21	0,7025	-1,2293	0,4832	-0,5895	0,6476	0,3168
469	29	14	0,6137	-2,2794	0,4813	-1,3095	0,7317	0,3268
470	29	24	0,7605	-0,7192	0,4718	-0,4995	0,5528	0,2877
471	29	19	0,5905	-1,9994	0,4706	-0,8395	0,714	0,3056
472	29	20	0,6294	-1,6894	0,4671	-0,7095	0,6893	0,3085
473	29	16	0,5906	-2,2994	0,4633	-1,2295	0,7389	0,3184
474	29	22	0,7135	-1,0993	0,4631	-0,6395	0,6267	0,3083
475	29	4	0,6808	-0,7193	0,463	-0,2695	0,6014	0,241
476	29	22	0,6814	-1,2593	0,4614	-0,6395	0,6364	0,3013
477	29	23	0,7145	-1,0093	0,4603	-0,6095	0,6005	0,2952
478	29	15	0,5817	-2,4494	0,4597	-1,3295	0,7449	0,3177
479	29	19	0,6093	-1,8894	0,4588	-0,8695	0,7107	0,3104
480	29	22	0,6659	-1,3293	0,4529	-0,6595	0,6424	0,2978
481	29	23	0,7363	-0,9193	0,4513	-0,6195	0,5959	0,2996
482	29	20	0,6026	-1,8394	0,4435	-0,7696	0,7015	0,3018
483	29	19	0,5485	-2,2695	0,4337	-0,9396	0,7333	0,2945
484	29	22	0,6537	-1,3893	0,4217	-0,7296	0,6517	0,2951
485	29	21	0,5826	-1,8594	0,4044	-0,7696	0,6972	0,2885
486	29	4	0,6544	-0,7993	0,3838	-0,3996	0,6204	0,2363
487	29	26	0,8213	-0,2892	0,3806	-0,3296	0,4606	0,2494
488	29	25	0,7652	-0,5892	0,3622	-0,5696	0,532	0,2675
489	29	24	0,6733	-1,0693	0,3495	-0,7597	0,6006	0,2707
490	29	25	0,7137	-0,7593	0,3437	-0,6097	0,5493	0,2584
491	29	2	1,237	0,5612	0,3374	-0,1697	0,4125	0,2408
492	29	24	0,6332	-1,2394	0,3288	-0,8097	0,6157	0,2625
493	29	27	0,7656	-0,2692	0,3272	-0,2297	0,4181	0,2051
494	29	26	0,7543	-0,4692	0,3248	-0,4197	0,4904	0,239
495	29	23	0,5557	-1,7694	0,3193	-0,9397	0,6724	0,2603
496	29	23	0,5543	-1,7694	0,3186	-0,9397	0,673	0,26
497	29	24	0,5934	-1,4094	0,308	-0,8597	0,6308	0,2541
498	29	25	0,6478	-0,9994	0,303	-0,6997	0,5756	0,2461
499	29	21	0,4251	-2,8496	0,2996	-1,0497	0,7626	0,2465
500	29	2	0,5021	-0,7595	0,1378	-0,5499	0,6014	0,1534

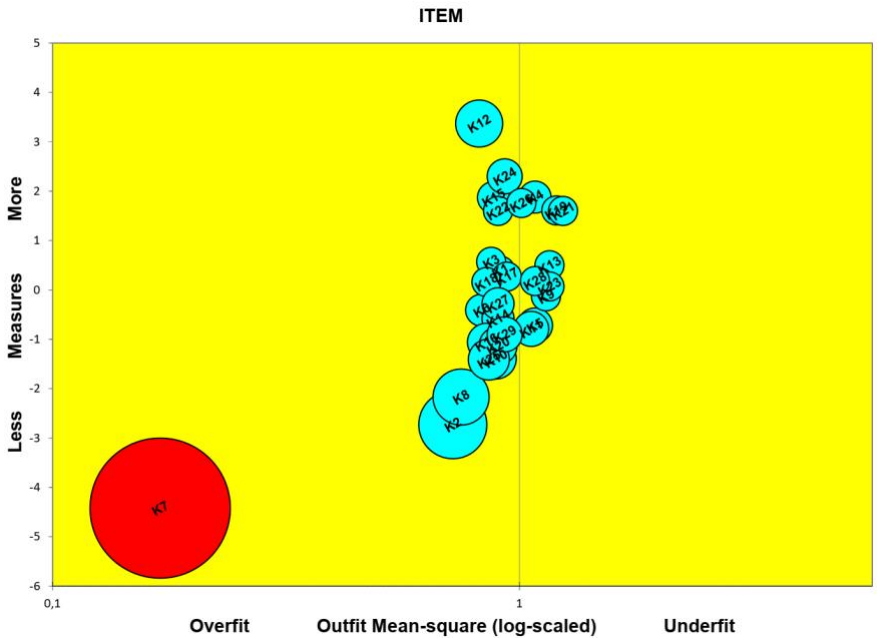
*MNSQ, mean-square; ZSTD, z-standard; PTMA, point measure correlation; RMSR, root-mean-square residual

Appendix D: Item fit measurement

ITEM	COUNT	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMA	RMSR
K21	500	1,1638	3,8012	1,2445	2,8512	0,1619	0,4755
K19	500	1,1503	3,4912	1,1986	2,3312	0,1793	0,4721
K13	500	1,1529	4,4612	1,1593	2,8112	0,2149	0,4937
K23	500	1,1144	2,7411	1,1563	2,3812	0,2447	0,4664
K9	500	1,1034	2,2011	1,1448	1,9911	0,2528	0,4508
K28	500	1,0647	1,6811	1,0803	1,3311	0,3005	0,4619
K5	500	1,0362	0,561	1,0801	0,8111	0,3048	0,3881
K4	500	1,032	0,671	1,076	0,8111	0,282	0,4291
K11	500	1,0053	0,101	1,0617	0,6111	0,3313	0,3756
K26	500	1,0279	0,631	1,0112	0,161	0,3027	0,4369
K17	500	0,9612	-1,069	0,9373	-1,0891	0,4067	0,443
K24	500	0,9661	-0,519	0,9312	-0,5591	0,3308	0,3801
K29	500	0,9705	-0,379	0,9309	-0,5891	0,3763	0,3579
K1	500	0,9129	-2,6191	0,9087	-1,6791	0,4523	0,4363
K20	500	0,9644	-0,399	0,9042	-0,7291	0,3718	0,3348
K22	500	0,9299	-1,7391	0,9023	-1,2291	0,4082	0,4251
K27	500	0,946	-1,0791	0,8994	-1,3291	0,4189	0,4072
K14	500	0,9682	-0,509	0,8963	-1,1291	0,3947	0,3871
K10	500	0,9618	-0,359	0,8945	-0,6891	0,3655	0,3086
K15	500	0,9242	-1,5991	0,8848	-1,2291	0,4009	0,4068
K3	500	0,9201	-2,5491	0,8682	-2,5491	0,4538	0,4427
K25	500	0,9401	-0,5791	0,8596	-0,9291	0,3877	0,3031
K16	500	0,9432	-0,6791	0,8541	-1,2091	0,4043	0,3377
K18	500	0,8986	-2,7191	0,8531	-2,5391	0,4718	0,4234
K6	500	0,8963	-1,9591	0,8284	-2,1792	0,4665	0,3867
K12	500	1,0108	0,131	0,8185	-0,9492	0,2358	0,2812
K8	500	1,0622	0,4611	0,7538	-1,0992	0,3019	0,2464
K2	500	1,1571	0,8312	0,7245	-0,8993	0,2272	0,2072
K7	500	0,8134	-0,3392	0,1682	-2,1798	0,3391	0,0866

*K, knowledge item; MNSQ, mean-square; ZSTD, z-standard; PTMA, point measure correlation; RMSR, root-mean-square residual

Appendix E: Item Fit Order for all items in AKAQ with 29 items (including item K7)



Appendix F: Differential Item Functioning (DIF) by term

Name	DIF CONTRAST	JOIN S.E.	Mantel-Haenszel		Size	Active slices	Item number	DIF classification
			Chi-squ	Prob.	CUMLOR			
K1	.48	.20	35.676	.0589	.41	17	1	
K2	.15	.49	.0381	.8453	.25	17	2	
K3	-.11	.20	12.489	.2638	-.26	17	3	
K4	.21	.21	13.190	.2508	.26	17	4	
K5	.19	.24	15.371	.2150	.35	17	5	
K6	.79	.24	80.784	.0045	.75	17	6	moderate to large
K8	.38	.41	.5901	.4424	.46	17	8	
K9	-.09	.21	.1518	.6969	.10	17	9	
K10	.54	.31	17.219	.1894	.45	17	10	
K11	.20	.25	.6843	.4081	.24	17	11	
K12	-.24	.32	.8380	.3600	-.35	17	12	
K13	-.51	.20	23.627	.1243	-.32	17	13	
K14	.29	.24	12.883	.2564	.31	17	14	
K15	-.49	.21	71.371	.0076	-.67	17	15	
K16	-.34	.26	29.951	.0835	-.53	17	16	
K17	.26	.20	12.682	.2601	.26	17	17	
K18	.32	.21	.8260	.3634	.22	17	18	
K19	-.67	.21	54.267	.0198	-.50	17	19	moderate to large
K20	.18	.27	.1096	.7407	.14	17	20	
K21	.15	.20	.9444	.3312	.22	17	21	
K22	.00	.20	.0772	.7812	-.08	17	22	
K23	-.29	.20	.7477	.3872	-.20	17	23	
K24	.27	.23	10.753	.2997	.28	17	24	
K25	-.45	.29	30.927	.0786	-.61	17	25	
K26	-.24	.21	.9016	.3424	-.22	17	26	
K27	.00	.22	.1131	.7366	-.10	17	27	
K28	-.22	.20	.3108	.5772	-.13	17	28	
K29	-.18	.25	.5311	.4661	-.22	17	29	

*K, knowledge item; DIF, differential item functioning; DIF S.E., standard error of the differential item functioning; Chi-squ, chi-square; Prob., probability; CUMLOR, cumulative log-odds ratio in logits;

Pharmacy Education (2024) 24(1) 79 - 90
https://doi.org/10.46542/pe.2024.241.7990

RESEARCH ARTICLE

Implementing a longitudinal poster project to engage pharmacy students beyond the classroom in a foundational sciences course

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Keywords
Active learning
Cooperative learning
Foundational sciences
Peer instruction
Pharmacy education
Poster project

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Abstract

Introduction: Poster projects and presentations can provide engagement and skill-building opportunities for students. A group poster project was incorporated into a first-year required genetics and pharmacogenomics course. Rough drafts were due for the project throughout the term, which coincided with course topics. The objective of this study was to determine the impact of a longitudinal poster project on pharmacy students' perceptions of learning, presentation skills, and success in future presentations. **Methods:** Students in a Doctor of Pharmacy programme were surveyed via Google Forms in 2018 before and after completing the poster project. The original cohort of students were surveyed again in 2020. Data were analysed with Graphpad Prism software. **Results**: Students responded positively to survey questions gauging their perception of the project's value as a learning tool, especially for reinforcing and applying course concepts. Overall, students saw the benefit of completing poster rough drafts and believed the poster was helpful in preparing and/or presenting future posters. **Conclusions**: A similar project could be built into any foundational course in a Doctor of Pharmacy programme. However, care should be taken to provide appropriate feedback and mentorship to students to optimise the benefits of learning and development of poster presentation skills.

Introduction

In recent years, numerous studies have reported the benefits of active learning and engagement activities for students, including in pharmacy degree programmes (Stewart *et al*., 2011). However, others have outlined the barriers to incorporating active learning into foundational pharmaceutical sciences courses in pharmacy degree programmes, including the concern that all required course content will not be covered if class time is allotted to active learning activities (Brazeau, 2004; Kennedy, 2019). In addition, there is a very limited amount of literature describing unique out-of-class approaches to support learning in these types of courses. Group projects, or formal cooperative learning, are examples of assignments where groups of students are expected to complete a task together over a given timeframe (Davidson & Katopodis, 2022). Group projects are a type of engagement activity that can be designed to use little to no class time while maintaining the benefits of active learning (Love *et al*., 2014). An added advantage of group projects is peer-to-peer instruction (Versteeg *et al*., 2019), which in the project described herein occurs during the preparation phase, as group members work together to identify and include appropriate information in an optimal format.

Posters are a widely accepted format for scientists and researchers to share their current research with a large audience in a formal setting (Sousa & Clark, 2019). While many types of projects could be used for

cooperative learning, poster projects, in particular, require students to retain and apply course content, as well as practice their oral communication skills in a format that they may use again in their career if they choose to conduct and share research as a clinical pharmacist (Grey *et al*., 2022). Professors from various institutions across the world have implemented poster projects into their courses over the past few decades, adapting poster projects and presentations for a wide array of disciplines, levels of education, and learning objectives (Hess & Brooks, 1998; Wheland *et al*., 2009; Rauschenbach *et al*., 2018). Within pharmacy degree programmes specifically, poster presentations have been incorporated into the didactic and experiential curricula in a variety of ways. Usually, poster presentations are used to summarise data derived from capstone projects, Advanced Pharmacy Practice Experiences (APPE), and research electives (Wuller, 2010; Ramsauer, 2011; Harirforoosh & Stewart, 2016; Henchey *et al*., 2020). However, they can also be utilised as projects within required didactic courses (Nowak, 1998). Most reported opportunities in pharmacy programmes that resulted in a poster presentation have been geared toward students in the later part of their professional education. This brings into question the impact that a poster presentation might have on pharmacy students if incorporated into a foundational pharmaceutical sciences course during their first professional year (PY1).

The majority of published studies regarding poster projects within pharmacy education have focused on involving pharmacy students in original research, requiring them to play a part in all phases of the project, from the project proposal, methods, data collection, and presentation (Hess & Brooks, 1998; Wheland *et al*., 2009; Rauschenbach *et al*., 2018; Henchey *et al*., 2020). One study within a Doctor of Pharmacy programme has assessed a poster project and presentation itself as an innovative learning tool independent of an original research experience. That study, published in 1998, describes a poster presentation that was implemented within a medicinal chemistry course (Nowak, 1998). In this example, second professional-year pharmacy students, in groups of three to four, worked on a project that culminated in a poster presentation and a term paper on a novel drug or drug target (Nowak, 1998). Overall, there is limited published research on this topic, especially in regard to pharmacy education.

As the realm of higher education evolves from instructors solely lecturing at the front of the room to a student-centred active learning model, pharmacy education staff are seeking out unique approaches that use minimal valuable lecture time to teach foundational concepts and connect them with clinical application. An out-of-class poster project assignment, such as the one described here with its novel design and curricular placement, maybe a beneficial educational tool that instructors could implement to reach that goal. The objective of this study was to determine the impact of a longitudinal poster project and presentation on students' perceptions of its effects on learning, presentation skills, and anticipated or actual success in future presentations. The approach to this study assessed perceptions over several years to determine if opinions regarding the poster project changed over time and whether students had applied skills learned during the process to subsequent poster projects.

Methods

The genetics/pharmacogenomics poster project and presentation discussed in this paper were developed as part of the required PY1 Principles of Genetics and Genomics course in a College of Pharmacy and Health Sciences (COPHS) at a private university. For the project, teams of six students chose any disease state that included a genetic component at the beginning of the term, which differed from other poster presentation topics for that year. Each part of the poster project (six parts total, including one section on Pharmacoeconomics that was graded separately) was due as a rough draft that should be worked on and submitted as a team sequentially throughout the term as related content is covered in the course. This process encourages students to work on the project longitudinally and provides touchpoints for mentoring students on the accuracy/appropriateness of content, as well as formatting. At the end of the term, each team has a chance to resubmit one of their rough drafts for a better grade (Redo) before the poster is finalised, allowing them to gain additional feedback before printing the poster and completing the final presentation. The presentations occur at a mock conference with COPHS faculty, other students, residents, and administrators to emulate what students might encounter if they present a poster at an academic conference. The rough drafts account for 60%, the final presentation accounts for 35% (Appendix A), and a quiz to ensure students review all posters accounts for 5% of the total poster grade. The poster is prepared in PowerPoint, and rough drafts are submitted to dropboxes where grading/feedback is provided.

The sections of the poster encompass various aspects of a disease state, including description, risk factors, testing, a summary of treatment options, pharmacology of one treatment option, and the

pharmacogenomics and pharmacoeconomics of the chosen treatment option. Although each student in the group presents one section of the poster and receives an individual grade, the project instructions recommend that the group works as a team on all rough drafts and the final poster format, which are graded as a group. The project requires students to review foundational concepts from the course and think critically about the therapeutic use of genetics/pharmacogenomics. Thus, the project was primarily developed to enhance students' understanding, retention, and clinical application of coinciding course concepts through the process of preparing and then presenting a poster. The secondary outcome of the poster project was to expose PY1 students to this process to help them develop the skills to design a poster from start to finish and enhance their verbal communication through the presentation.

Several electronic surveys were utilised in this study to assess student perceptions regarding these aspects of the poster project. These surveys were developed based on similar published questionnaires as templates (Marcinak *et al*., 2018). Efforts were made to optimise the length (pre/post - 16/12 questions, follow-up - 18 questions) and clarity of the surveys to obtain meaningful data, as well as improve response rates. PY1 students were surveyed in the spring of 2018 at the start of the course and after they completed the poster project. Respondents were asked to choose a unique six-digit number to match their pre- and post-survey responses for optimal analysis and to maintain anonymity. To optimise response rates, for the pre/post surveys, students received a 0.5% bonus on their final grade for the course for each survey completed, for a potential total of 1%. Students who did not wish to participate were provided with a different assignment (equal in time and effort to the survey) for an equal bonus in the course. The recruitment e-mail indicated that each survey should take approximately 15 minutes to complete for a total of 30 minutes for 1% bonus. One student chose to complete the alternative assignment instead of taking either survey. For this assignment, they were asked to write a brief summary (about half a page) on the topic of the use of presentations and posters to benefit students. Students who only responded to either the pre-survey or the post-survey were excluded from the results. Students were provided information about each survey in an initial e-mail with no reminders and given one week to respond. The purpose of the pre- and post-surveys was to assess the students' perception of the benefit of the project toward their understanding, retention, and clinical application of genetics/pharmacogenomics course concepts, as well as their perception of the impact of the project on their confidence presenting future posters, and the value of having assigned drafts for the project. This was followed up in the summer of 2020 by surveying the same cohort that was enrolled in the course in 2018 to assess their perception of the project several years later. Again to optimise response rates, students who completed the follow-up survey were able to submit their names through a separate link for a chance to win a $25 gift card. Thus, responses to this survey were also anonymous. Students were provided information about the follow-up survey in an initial e-mail, sent two e-mail reminders, and given three weeks to respond. Participation was not required, so reasons for non-response were not collected for any of the surveys.

Data were collected through Google Forms and analysed through the GraphPad Prism software (Version 8). Likert scale questions were converted to numerical data (Strongly Disagree = 1, Disagree = 2, Neither Agree nor Disagree = 3, Agree = 4, and Strongly Agree = 5) for statistical analysis to compare pre and post-survey responses. The D'Agostino-Pearson normality test was used to assess the normality of each data set. Normally distributed data were compared using either unpaired *t*-tests with Welch's correct or paired t-tests. Data not normally distributed were compared using Mann-Whitney tests or Brown-Forsythe and Welch's ANOVA. Follow-up survey data were reported with descriptive statistics only. Post hoc analyses were conducted to see if future plans or previous poster experience affected any of the outcomes. This research was approved by the COPHS Institutional Review Board (COPHS-IRB# 28 and 92).

Results

There were 60 first-year pharmacy students enrolled in this course in 2018 who participated in and completed the project. Fifty-nine students completed the pre-survey, and 56 students completed the post-survey. Based on the six-digit code, 45 participant pre/post surveys were matched, resulting in a final response rate of 75% (N = 45). The response rate for the follow-up study of the original cohort as PY4 students in 2020 was 45% (N = 27). The demographics of student respondents are shown in Table I. The majority of respondents in the pre and post-surveys were female (77.8%, N = 35), which is similar to the 71.7% of females in that cohort, and had no previous degree (82.2%, N = 37). In their first year, most respondents planned to either complete a post-graduate residency or become employed at a community pharmacy upon graduation, and this remained true in their fourth year (PY4, follow-up survey), with slight changes in percentages.

Table I: Demographics of survey respondents

	PY1[a] (n = 45) Pre/Post-survey n (%)	PY4[b] (n = 27) Follow-up n (%)
Age (years)		
Under 20	20 (44.4)	
21 - 24	19 (42.2)	
25 - 30	4 (8.9)	
31 - 40	2 (4.4)	
Over 41	0 (0)	
Gender		
Male	10 (22.2)	
Female	35 (77.8)	
Previous education		
Pre-pharmacy/Prerequisites	37 (82.2)	
Bachelor's degree	7 (15.6)	
Master's degree	0 (0)	
Doctor of Philosophy degree	0 (0)	
Other	1 (2.2)	
Future plans		
Post-graduate residency	14 (31.1)	12 (44.4)
Post-graduate fellowship	2-3 (4.4 - 6.7)	1 (3.7)
Employment in community	13-16 (28.9 - 35.6)	12 (44.4)
Employment in a hospital	7-9 (15.6 - 20.0)	1 (3.7)
Other	5-7 (11.1 - 15.6)	1 (3.7)

[a]PY1 = first professional year; [b]PY4 = fourth professional year

Overall, students responded very positively to survey questions gauging their perspective on the project's value as a learning tool, specifically in regard to reinforcing course concepts (88.9% and 88.9% agreed/strongly agreed in pre- and post-surveys, respectively) and improving their ability to apply (88.9 and 93.3% agreed/strongly agreed in pre- and post-surveys, respectively), and retain such concepts (82.2 and 82.2% agreed/strongly agreed in pre- and post-surveys, respectively), as shown in Table II. Students responded significantly more in agreement to the statement on applying course concepts in the post-survey than in the pre-survey. However, there were only slight but insignificant increases in agreement for reinforcing and retaining course concepts in the pre- and post-surveys. Although levels of agreement waivered in the follow-up (PY4) survey for these statements, a majority of respondents still agreed/strongly agreed that the project reinforced (85.2%), as well as helped them to apply (81.5%) and retain (70.4%), course concepts (Table II).

Table II: Survey respondent perspectives on usefulness of the project as a learning tool.

	PY1[a] (n = 45)		PY4[b] (n = 27)
	Pre-survey M (SD)[c, d]	Post-survey M (SD)	Follow-up M (SD)
Completing the poster project will/did help reinforce course concepts.	4.13 (0.59)	4.31 (0.73)	4.07 (0.62)
Completing the poster project will/did help me apply the course concepts.	4.18 (0.61)	4.44 (0.69)[e]	4.04 (0.76)
Completing the poster project will/did help me retain the course concepts.	4.09 (0.67)	4.18 (0.94)	3.70 (1.03)
Rough drafts of sections due over the term will be/was a useful way to complete the poster and prepare for the presentation.	4.18 (0.65)	4.76 (0.48)[e]	4.52 (0.58)
Looking back on the group effort, everyone contributed to preparing the final poster.			4.00 (1.11)
Looking back, all members of the group contributed equally to all sections of the poster project.			3.63 (1.24)

[a] PY1 = first professional year; [b] PY4 = fourth professional year; [c] Likert scale key: 5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree; [d] Mean (Standard deviation; [e] $p < 0.05$ Comparison of post-survey results with pre-survey results

Delving into the project layout, students saw rough drafts being due throughout the term as useful (86.7% and 97.8% agreed/strongly agreed in pre- and post-surveys, respectively) (Table II). As anticipated, PY1 students responded significantly more in favour of rough drafts in the post-survey. The respondents in the follow-up (PY4) survey also overwhelmingly responded in favour of rough drafts as a useful way to complete the project, with 96.3% of students choosing to agree/strongly agree. Students were generally successful in scoring rough draft sections, and this improved further after the allowed one rough draft section redo (seven out of ten teams chose to redo a section of their posters, none for section one, two for sections two to four, and one for section five), suggesting that they had learned from the process and were able to make corrections, both in content and formatting (Table III). Students also excelled at their poster presentations, which were evaluated based on printed and orally presented information, poster formatting, and presentation skills (Table III). Finally, although a direct correlation of final grades to the poster project cannot be completed due to confounding variables, students did well in the course, with a class average of 81.8, and only one-course failure after normalising for the bonus points received for completing the surveys (Table III).

Table III: Student performance for the poster project and in the course

	Before redo	After redo	*p*-value[b]
	M (SD) or N		
Rough drafts			
Section 1	90.0 (5.5)	NA	
Section 2	86.7 (8.0)	91.5 (5.1)	0.0005
Section 3	84.0 (14.4)	91.0 (9.5)	0.0005
Section 4	87.5 (6.5)	91.5 (6.8)	0.0005
Section 5	84.0 (6.3)	85.5 (6.9)	0.03
Poster presentation		91.4 (1.2)	
Final poster grade		90.9 (1.3)	
Final course grade[a]		81.8 (6.2)	
Final course letter grade (As, Bs, Cs, Fs)[a]		10, 25, 24, 1	

[a] Normalised for bonus given for completing survey; [b] Before versus after redo

Digging deeper into how the teams approached the project, students in the follow-up (PY4) survey were also asked to reflect on team members' contributions to the project (Table II). These questions ('*Looking back on the group effort, everyone contributed to preparing the final poster*'; '*Looking back, all members of the group contributed equally to all sections of the poster project*') sought to deduce whether students split the project up by rough draft sections or if there was collaboration among the team members on each of the required drafts and hence learning about all topics by all students. Overall, the majority of students in the follow-up (PY4) survey agreed/strongly agreed with both statements, although fewer students agreed to the second statement compared to the first (81% and 63% agreed/strongly agreed, respectively) (Table II). Open response feedback was also solicited from the follow-up (PY4) survey respondents in regard to why students did or did not contribute equally to all sections of the project. The student comments focused on two main themes: (1) Mastery of course concepts (or lack thereof) impacted the ability to contribute to the project, and (2) Rough draft sections were not equally difficult, leading to unequal contribution.

Aside from gauging the perceived usefulness of the project as a learning tool, the perceived value of the project as a stepping-stone for future poster presentations was also assessed. Two-thirds of PY1 students who responded to the survey had no experience with a previous poster presentation (Table IV). Given this limited amount of previous experience, almost all PY1 students agreed in both the pre- and post-surveys that preparing and presenting the project would help them prepare and present future posters (93.3% and 100% agreed/strongly agreed for preparing; 93.3 and 95.6% agreed/strongly agreed for presenting, in pre and post-surveys, respectively) (Table V). When assessing students' perceptions of their confidence in presenting a poster, the responses were varied (Table V). Only 37.8% of PY1 respondents agreed/strongly agreed that they were confident in their poster presentation skills prior to the start of the course,

which unexpectedly increased to 62.2% in the post-survey. However, 88.9% of respondents already agreed/strongly agreed in the pre-survey that the poster project would increase their confidence level to present a poster in the future. This percentage was even higher in the post-survey, indicating that the project did increase their confidence (Table V).

Table IV: Previous and subsequent poster presentations completed by survey respondents

	PY1[a] (n = 45) Pre/Post-survey n (%)	PY4[b] (n = 27) Follow-up n (%)
Presentations before project		
Zero	30 (66.7)	19 (70.4)
One	5 (11.1)	2 (7.4)
Two	2 (4.4)	4 (14.8)
Three	3 (6.7)	1 (3.7)
Four or more	5 (11.1)	1 (3.7)
Presentations after project		
Zero		0 (0.0)
One		15 (55.6)
Two		3 (11.1)
Three		5 (18.5)
Four or more		4 (14.8)

[a] PY1 = first professional year; [b] PY4 = fourth professional year

Table V: Survey respondent perspectives on usefulness of the project in regard to future projects

	PY1[a] (n = 45)		PY4[b] (n = 27)
	Pre-survey M (SD)[c, d]	Post-survey M (SD)	Follow-up M (SD)
Preparing the genetics poster presentation project will/did help me prepare future posters.	4.33 (0.60)	4.53 (0.50)[e]	3.89 (0.70)
Presenting the genetics poster presentation project this term will/did help me present future posters.	4.36 (0.77)	4.60 (0.65)	4.04 (0.65)
I feel/felt confident in my poster presentation skills (before the genetics poster presentation project).	3.18 (0.91)	3.56 (0.94)[e]	3.22 (0.89)
Presenting the genetic poster project will/did increase my confidence level in presenting a poster in the future.	4.04 (0.82)	4.38 (0.72)[e]	3.85 (0.60)
I would/do include the genetics poster presentation project on my resume/CV.	3.42 (0.97)	3.71 (0.99)[e]	3.70 (1.32)

[a] PY1 = first professional year; [b] PY4 = fourth professional year; [c] Likert scale key: 5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree; [d] Mean (Standard deviation); [e] $p < 0.05$ Comparison of post-survey results with pre-survey results

A majority of respondents in the follow-up (PY4) survey still indicated that they had completed no poster presentations before the described project and all of the respondents reported that they had completed at least one poster presentation after the conclusion of the course, with almost half of those having completed two or more posters (Table IV). This was an expected response as students were required to complete a poster presentation for an unrelated second-year course in the curriculum, and many worked on other research projects with faculty and preceptors that they presented at professional meetings. When asked how completing the genetics/pharmacogenomics poster project had affected those subsequent projects, although these percentages decreased to some extent compared to PY1 responses, a majority of PY4 respondents agreed/strongly agreed to the usefulness of this experience for both preparing and presenting future posters projects (77.8% agreed/strongly agreed for preparing, 81.5% agreed/strongly agreed for presenting) (Table V). Only 44.7% of respondents agreed/strongly agreed that they had felt confident in

their presenting skills before the poster project, which is similar to pre-survey PY1 responses for this question. In addition, although a smaller percentage than for PY1 responses, approximately three-quarters (74.1%) of respondents in the follow-up (PY4) survey still agreed/strongly agreed that the poster project had increased their confidence to present future posters (Table V).

Finally, respondents were asked if they would list the genetics/pharmacogenomics poster on their resume/CV as an indicator of their perception of its value. The PY1 students who responded to the pre- and post-survey generally were neutral (37.8% in the pre-survey; 33.3% in the post-survey) or agreed/strongly agreed (48.9% in the pre-survey; 57.8% in the post-survey) that they would include the project on their resume/CV, with the number of students in agreement increasing slightly after completing the project (Table V). Interestingly, more students agreed with this statement in the follow-up (PY4) survey, with 70.4% of students agreeing/strongly agreeing that they included the genetics/pharmacogenomics poster presentation on their CV. Post-hoc analyses were conducted on this dataset to assess whether or not post-graduate plans had any bearing on the value that students placed on this project as a component of their resume/CV and they did not appear to be related.

Discussion

Engaging students with course content beyond typical didactic lectures can improve understanding and learning (Davidson & Katopodis, 2022). An out-of-class poster project assignment that requires students to apply course concepts to a research topic is an example of an engaging teaching approach that does not require a significant amount of class time, which is a concern for pharmaceutical sciences faculty teaching in pharmacy programmes (Kennedy, 2019). Additionally, group projects support cooperative learning as students work together to understand and apply their knowledge (Johnson *et al*., 2014). Cooperative learning improves several outcomes, including higher achievement, more productivity, better processing of information, and more effective interpersonal skills (Johnson & Johnson, 2009). This is most effective when the format of the project requires both interdependence and individual accountability, as well as monitoring by the instructor, all aspects that are incorporated in the poster project described here. Poster projects and presentations have been used to achieve the following educational outcomes: improving scientific communication skills (Hess & Brooks, 1998; Nowak, 1998; Taylor *et al*., 2003; Wheland *et al.,* 2009; Morris *et al*., 2011; Gruss, 2018; Rauschenbach *et al*., 2018), facilitating peer instruction and learning (Hess & Brooks, 1998; Nowak, 1998; Wheland *et al*., 2009), reinforcing course concepts (Morris *et al*., 2011; Gruss, 2018), applying course concepts clinically (Nowak, 1998; Wuller, 2010; Ramsauer, 2011), and fostering an interest in research and research culture (Nowak, 1998; Morris *et al*., 2011; Harirforoosh & Stewart, 2016; Henchey *et al*., 2020). Thus, for a variety of reasons, implementing a poster project into a didactic course in a pharmacy degree programme could be beneficial for students. It can function as a learning tool, enhance depth of understanding, and serve as a stepping-stone to future poster presentations.

There are strictly pedagogical benefits seen with incorporating projects into a university-level course, which can be examined through the context of Bloom's taxonomy. The revised Bloom's taxonomy (RBT) classifies the process of thinking and learning into six distinct levels: remembering, understanding, applying, analysing, evaluating, and creating (Krathwohl, 2002). When considering pharmacy education on a larger scale, the overall objective is to produce competent practitioners, but from a strictly pedagogical point of view, this end goal requires mastery of biological sciences, pharmaceutical sciences, social/administrative sciences, and clinical sciences (Accreditation Council for Pharmacy Education (ACPE), 2015). Within a biological or pharmaceutical science course, mastery of analysing, evaluating, and creating requires deep learning, which is hard to achieve in courses assessed strictly through examination (Cain *et al*., 2022). Projects like the poster project and presentation described in this paper can help bridge the gap between the lower and upper tiers of RBT, which can help students master concepts that are important for their future success as pharmacists.

To assess student perceptions of the poster project's effects on learning, students were surveyed in three specific domains related to course concepts: reinforcement, application, and retention. Reinforcement is an important component of understanding, which makes up a fundamental base for the other two domains, as depicted in Bloom's taxonomy (Krathwohl, 2002). Application and retention, on the other hand, are both essential for students to be able to use their knowledge in their professional pharmacy practice. When surveyed on these topics, the majority of students agreed that the project helped them reinforce, apply, and retain course concepts, in the pre, post, and follow-up surveys. The lowest rates of agreement were in response to the retention question, which exhibited a drop-off between the post-survey and the follow-up survey. This

was somewhat expected based on what is known of memory and the Ebbinghaus forgetting curve, which mathematically depicts how people quantitatively forget information over time (Murre & Dros, 2015). That being said, without a comparator group to assess, it is uncertain if students who learned exclusively through lectures would have better or worse retention than the students who explored the course content through the poster project.

In addition to the questions regarding learning, a smaller percentage of PY4 respondents agreed/strongly agreed with the questions regarding how the poster project may have helped them with future projects, as compared to PY1 responses. Although there are several potential reasons for these differences, in addition to the Ebbinghaus forgetting curve mentioned above, it is important to note that a majority of PY4 respondents still agreed with these questions. The two questions for which responses did not decrease in agreement were regarding using rough drafts for the poster project and whether they included the presentation on their CV. These results support the conclusion that the format of this project works especially well and that the students overall found value in the project for both learning course content and building helpful skills.

One of the logistical challenges of having a poster presentation project is making sure students stay on track throughout the term. The two biggest factors that may affect this are the use of rough drafts and the degree of mentorship the students receive through timely feedback from the instructor. The project described in this paper utilised rough drafts of each section of the poster throughout the term, which were viewed as highly useful by the students both prospectively and retrospectively. At face value, rough drafts are a tool to encourage time management. Looking beyond that, rough drafts are also an opportunity for mentorship, as this allows the instructor to provide individual feedback to each group to enhance their understanding of the course material as it applied to their individual disease state and assess the completeness of their information. Thus, as students progress through a longitudinal project, it is imperative that instructors ensure that they have enough feedback and guidance to succeed.

A piece that comes into play in terms of the feasibility of providing mentorship is group size. Groups must be big enough that providing individualised feedback is possible for the instructor but not so big that they are a logistical nightmare for the students. The project described in this paper used groups of six students, but with a smaller class size or the introduction of additional mentors (additional pharmacy education staff or residents), smaller groups could be possible. In a similar project described by Nowak (1998), groups consisted of three to four students, with other papers describing groups as small as individual students (Gruss, 2018). One technique to reduce the mentorship burden on the pharmacy education staff member, demonstrated by Nowak (1998), was splitting the class into Fall presentations and spring presentations, which was successful but also only possible because the course in question spanned both terms under the same instructor. For courses that only span a single term, this is not an option; thus, adding more mentors or limiting the topics covered by the poster may be possible solutions to reduce group sizes.

Besides pedagogical benefits, incorporating a poster project into the didactic curriculum of a pharmacy programme has other potential benefits for pharmacy students. One of the novel components of this particular project is the unique timing in the curriculum. The majority of poster projects integrated into pharmacy curricula are introduced as upper-level electives or capstone experiences (Wuller, 2010; Ramsauer, 2011; Harirforoosh & Stewart, 2016; Henchey *et al*., 2020). Comparatively, the project described by Nowak (1998) occurs in the second professional year. The project described here occurs in the first professional year and requires students to utilise literature (e.g. Pubmed) and other databases (e.g. PharmGKB), as well as identify accurate, data-supported, and relevant information while investigating the diseases and drugs they are presenting. Furthermore, students learn to prepare, print, and present a professional poster.

Although there are printing and size requirements for this poster project, students are otherwise free to format the content of their posters how they wish. This allows them to be creative in the development of the poster, incorporating new approaches, and learning what works well and does not work well as they present their own poster and view their peers' posters. During the COVID-19 pandemic, students were able to present their posters virtually since they were prepared as PowerPoint files. These aspects are important as, more recently, there has been a switch to more viewer-friendly approaches to poster styling and digital poster presentations with the establishment of distance learning programmes, as well as increased virtual professional meetings and work settings (Persky, 2016; Newsom *et al*., 2021). Completing this process can help students build skills that apply to their future pharmacy education and careers.

In support of this, students with varying levels of experience prior to the project became equally confident in their ability to prepare and present a

poster by the end of the term, which may include skills such as gathering information using databases, creating a digital poster file, presenting a poster, and working in a team. In the pre-survey, the majority of students who had no previous poster presentation experience responded neutrally regarding poster presentation skills, whereas the majority of students who had previous poster presentation experience responded in agreement in the pre-survey. Comparatively, by the time the project was completed, there was no difference in how the two groups remembered their pre-project presentation skill set. From this, it can be inferred that completing a single poster presentation can alter students' perceptions of their own skills and competence, levelling the playing field between students with a single project. This sets the stage for students to pursue similar types of projects on their own and supports the importance of introducing a project like this early in the curriculum for maximum benefit in honing the students' presentation skills and confidence.

One of the major limitations of this study is the scope; just one project within one course in one college of pharmacy was assessed. The primary goal was to evaluate how students perceived the project as a learning tool and thus, the survey questions focused on ties between the project and the course the students were taking, when in fact, the project had the interdisciplinary component of a Pharmacoeconomics poster section evaluating three to four studies focused on the cost-effectiveness of the pharmacological therapy chosen by the team to highlight in their poster. The rough draft for this section is reviewed by the pharmacy outcomes instructor of record, and the grade for that section of the poster is utilised for that course. The purpose of integrating the poster project in this manner was to facilitate an appreciation for each course by connecting them with other pharmaceutical sciences. The value of this component was not gathered based on the questions asked and could be an area of future inquiry. In addition, the survey questions were not validated per se, although they were based to some degree on an analogous published study, and the similarity in results overall between the post and follow-up surveys does support the soundness of the results and conclusions described herein.

Furthermore, while there is a perceived benefit of this project for learning and application of course concepts, this is not an objective measure. However, since this course has never been run without this poster project it is difficult to directly assess the effects of the project on learning outcomes beyond reporting grades earned on the project and for the course overall. Although the survey did assess how the work was split up amongst team members, it did not collect data on each respondent's individual participation. Thus, this aspect was not taken into account in the study. Finally, selection biases may have been introduced through a few possible ways, such as PY4s who had completed research projects on rotation potentially being more inclined to respond to the survey or by providing a bonus or opportunity to win a gift card for respondents. In an effort to overcome at least some of this bias, the informed consent letters indicated that responses were anonymous and would be published in aggregate.

Conclusion

Engaging students with course content through a poster project in a foundational pharmaceutical sciences course in a pharmacy degree programme could be beneficial for students in a variety of ways. A similar project to the one described in this paper could be built into any biological or pharmaceutical science course in a pharmacy degree programme with comparable benefit to the students, but care should be taken to promote interdependent and individual accountability, as well as provide appropriate structure for feedback and mentorship to students.

Acknowledgement

The authors would like to thank those who responded to the surveys and are appreciative of the review and constructive comments on the manuscript provided by Dr. Daniel Kennedy of Western New England University.

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Appendix A: Grading rubric for genetics and genomics posters

Topic:

Evaluator name:

(information provided in the poster and presented should be at the level that is understandable to a College of Pharmacy and Health Sciences professor, but not an expert)

Section 1) Group assessment – Genetics and pharmacogenomics content (pharmacoeconomics content on separate rubric)

	Poor (2.5 pt)	**Fair (5 pts)**	**Good (7.5 pts)**	**Excellent (10 pts)**
1) Description/ Background/ Symptoms *Score*_____	Definition of the genetic disorder is given. No use of scientific terminology in order to further explain the disorder. Medical and behavioral symptoms inadequately described.	Basic description/ definition of genetic disorder. Scientific terminology is used but rarely explained. Medical and behavioral symptoms are listed with few descriptions.	Description of genetic disorder given using scientific terminology that is not explained fully or in simple terms. Most medical and behavioral symptoms are listed as well as descriptions of some.	Full description of genetic disorder. Detailed information written in simple terms in which an audience could understand. Explanation of any scientific terminology. Medical and behavioral symptoms completely and accurately described.
2) Risk factors/ Inheritance/ Testing/ Screening *Score*_____	Recurrence risk and inheritance inadequately described. Lists diagnostic tests but does not explain them.	Mentions risk factors and inheritance without elaborating and explaining them. Gives yes or no explanation for detection of genetic disorder.	Explains specific type of inheritance (dominant, recessive, chromosomal deletion, sex-linked, etc.) Tells briefly how it is detected. Screening methods listed and explained.	Explains specific type of inheritance as well as explains in detail what this type of inheritance is. Explains how it is detected in detail. Screening methods listed and explained.
3) Treatment/ Counsel/ Support *Score*_____	Cursory mention of treatments and support for people with this disorder.	More than one aspect of treatment or care unclear or missing.	Good explanation of treatments and support, but something unclear or missing.	Thorough explanation of treatments and support available for people with this disorder
4) Pharmacology and background of one treatment *Score*_____	Basic description of drug is given. No details are given regarding the background and development of the drug. Mechanism of action and uses inadequately described.	Basic description and background of drug. Minimal details regarding development of the drug. Mechanism of action and uses are listed with few descriptions.	Basic description, background, and development of drug is given, but is not explained fully or in simple terms. Mechanism of action and uses are listed as well as some detailed descriptions.	Full description of drug including background and development. Detailed information written in simple terms in which an audience could understand. Mechanism of action and uses completely and accurately described, including a figure that describes mechanism.
5) Pharmaco-genomics of one treatment *Score*_____	PGx of metabolism, transport, and/or PD inadequately described. Consequences are unclear.	PGx of metabolism, transport, and/or PD briefly described. Consequences are listed without elaborating or explaining them.	PGx of metabolism, transport, and/or PD described fully. Consequences are listed without elaborating or explaining them.	PGx of metabolism, transport, and/or PD described fully. Consequences are listed with full explanation and details.

Section 2) Group assessment – delivery

	Poor (2.5 pt)	Fair (5 pts)	Good (7.5 pts)	Excellent (10 pts)
1) Organisation *Score*_____	No organisation and extremely challenging to understand layout.	Poster is not so easy to read AND the information is disorganised and hard to follow.	Poster is not so easy to read or the information is disorganised and hard to follow.	Poster is easy to read with information presented in a logical manner.
2) Graphics *Score*_____	Minimal graphics with little or no content value.	Poster has few graphics or the graphics are arranged poorly.	Poster includes appropriate graphics that are misplaced or do not help with understanding.	Poster includes appropriate graphics, including images and graphs that attract attention and enhance understanding.
3) Writing mechanics *Score*_____	Three to five typos or grammatical errors. Proof-reading lacking	Three to five typos or grammatical errors.	Two typos or grammatical errors.	No typos or grammatical errors.
4) Sources *Score*_____	No bibliography.			Complete, properly formatted bibliography.

Section 3) Individual assessment rubric

	Needs lots of work and practice (2.5 pts)	Room for improvement (5 pts)	Accomplished (7.5 pts)	Exemplary (10 pts)
Delivery of presentation	Bare minimums have been accomplished. Little understanding about the topic delivered in oral presentation. Could only read poster with no further understanding.	Minimums plus slight extras added. Answered questions and shows some knowledge of the topic.	All information present and complete. Some problems with flow and delivery. Shows more or less some understanding of knowledge - has minor flaws.	Information is well thought out, flows well, all information is complete. Appears to have been practiced, knowledge of disease state, genetics, therapy, and PGx are appropriate.

Presenter section one (Disease description, background, pathophysiology, and symptoms)

Name: Score: _____ / 10

Comments:

Presenter section two (Risk factors, inheritance, screening, diagnostic testing)

Name: Score: _____ / 10

Comments:

Presenter section three (Overview of treatment options (including pharmacological therapies), counselling, and support)

Name: Score: _____ / 10

Comments:

Presenter section four (in-depth pharmacology and background of one treatment option)

Name: Score: _____ / 10

Comments:

Presenter section five (pharmacogenomics of the SAME treatment option)

Name: Score: _____ / 10

Comments:

Pharmacy Education (2024) 24(1) 91 - 145
https://doi.org/10.46542/pe.2024.241.91145

RESEARCH ARTICLE

Non-virtual simulation training and patient simulation existing for pharmacy students: A scoping review

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Keywords
Active learning
Pharmacy education
Simulation training
Skill

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Abstract

Background: Simulation training enhances non-technical skills and patient safety in pharmacy education, fostering healthcare knowledge and interprofessional collaboration. These training programmes are crucial for instructing pharmacy students in establishing therapeutic and interprofessional relationships with patients and healthcare providers. The objective of this scoping review was to examine not only the simulation training activities currently available to pharmacy students but also their effectiveness and then to identify areas in non-technical skills that still need to be taught. **Methods:** A scoping review focused on "*simulation training*" and "*pharmacy students*" was conducted, excluding virtual simulation. Initial searches in Scopus, MEDLINE and ERIC were performed on June 6, 2020, with a follow-up on February 25, 2022. Both English and French articles were considered, guided by PRISMA-ScR. **Results:** From 812 initial papers, 140 met inclusion criteria, revealing two simulation modalities: simulated patient and hybrid. Hybrid modality facilitated interprofessional simulation. Simulation training in patient communication, medication counselling and interprofessional education was seen to have the most impact on students. **Conclusion:** Simulation training was found to be an efficient method of teaching non-technical skills such as communication, medication counselling and interprofessional collaboration for patient-centred care and interprofessional exchanges in pharmacy education programmes.

Introduction

A number of different educational training programmes, such as simulation training, have been widely implemented in a number of areas of medical education to improve healthcare skills (McInerney *et al*., 2022). Simulation training involves replacing or amplifying real experiences with guided ones that replicate likely interactions in the professional workplace in an interactive manner (Gaba, 2004). In fact, this form of training has become more and more widespread as it allows healthcare students to practice and hone their skills in a controlled and low-risk environment before engaging with actual patients (Barry Issenberg *et al*., 2005; McGaghie *et al*., 2010). Simulation training has been found to be particularly valuable in assessing skills, team training, enhancing confidence, decision-making (Boulet *et al*., 2010) and developing relational skills. Patient communication and relational skills, also known as emotional intelligence (Soft Skills, empathy, etc.), play a crucial role in fostering patient-medical staff relationships, therapeutic adherence, and improving therapeutic outcomes. Previous studies have noted that the outcome of an interaction between a patient and a pharmacist depends on the pharmacist's ability to use the correct communication and counselling skills (Shah & Chewning, 2006; Mafinejad *et al*., 2017). The

community pharmacist is an accessible healthcare provider whose advice is highly sought-after. In addition to providing appropriate medication and treatment advice, a pharmacist must be able to respond appropriately to patients' demands and promote healthcare. This means that he also needs to be capable of interacting effectively with all members of a multidisciplinary medical team.

The terminology of the simulation modalities used was based on Chiniara's taxonomy and conceptual framework (Chiniara *et al*., 2013). A number of different modalities were employed to define the characteristics of simulation, including computer-based simulation, procedural simulation, simulated clinical immersion (SCI) and simulated patient (SiP). Additionally, hybrid modality (HM) was used which refers to a simulated experience combining two or more simulation modalities (Chiniara *et al*., 2013).

Visualising the practical applications of simulation training in non-technical skill development is crucial, but these fields have not been exhaustively described to date. There is currently no comprehensive overview of the various applications of live person-person simulations that are currently used to educate pharmacy students.

In a community pharmacy, the pharmacist interacts in person with both patients and medical colleagues. For this reason, this study focused on non-virtual live person-person simulation training scenarios: a SiP interacting with a pharmacist (played by a pharmacy student) or an interprofessional role play (IPR) that integrated multiple simulation modalities for patient care provision (Chiniara *et al*., 2013). The HM incorporated a minimum of one simulation modality alongside the IPR, such as SiP, computer-based simulation, procedural simulation, or SCI. SiPs are either actors or actual patients who have assumed the role of a patient in a pre-determined situation.

A scoping review is the method of choice for identifying knowledge gaps in the literature (Munn *et al*., 2018). This scoping review mirrored other studies that have demonstrated the benefit of virtual training in pharmacy education (Beshir *et al*., 2022). The results provide an overview of existing non-virtual reality simulation training and patient simulation for pharmacy students and describe the different areas of non-technical skills that are taught as part of pharmacy education. This currently includes patient communication, medication counselling and interprofessional education. In addition, their impact was examined and gaps in simulation training activities in these areas were identified.

By reviewing the existing literature on simulation training in pharmacy education, this review aimed to highlight the main areas of application in simulation training and come up with potential topics for future research. It was hoped that filling these gaps would improve current simulation training programmes for pharmacy students, equipping them with the skills they require to provide high-quality care for their patients.

Methods

Before starting the scoping review, the following databases were searched in June 2020 for existing scoping or systematic reviews on the topic: Cochrane Library, Prospero, Scopus (via Elsevier), MEDLINE (via Pubmed), ERIC (via Ovid), Epistemonikos, Campbell Library and JBI Evidence synthesis. None were found. Ethics approval was not required.

Design

This scoping review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines extension for Scoping Reviews (PRISMA-ScR) (Tricco *et al.*, 2018). The PRISMA-ScR checklist was used to perform the analysis and the protocol has been registered on the Open Sciences Framework (Registration DOI 10.17605/OSF.IO/G5VPW).

Search strategy

Three bibliographic databases, MEDLINE (via Ovid), ERIC (via Ovid) and Scopus (via Elsevier), were searched for articles in both English and French on June 6, 2020. A second search was carried out on February 25, 2022. The search strategy was made up of two key concepts: (1) simulation training and (2) pharmacy students. The complete search strategy can be found in the supplementary material section (Figure 1).

Ovid MEDLINE(R) ALL <1946 to March 25, 2022> - Search strategy
1 Students, Pharmacy/
2 Education, Pharmacy/
3 ((pharmacy or pharmaceutic*) adj3 (student* or education)).ti,ab,kf.
4 1 or 2 or 3
5 exp Simulation Training/
6 Role Playing/
7 (simulat* adj3 (training* or patient* or environment or education or high-fidelity or interprofession-al)).ti,ab,kf.
8 (role adj1 playing*).ti,ab,kf.
9 ((interact* or simulat*) adj3 learning).ti,ab,kf.
10 (standardi* adj1 patient*).ti,ab,kf.
11 5 or 6 or 7 or 8 or 9 or 10
12 4 and 11
SCOPUS (via Elsevier) – Search strategy
TITLE-ABS-KEY (((simulat*) W/2 (training OR patient OR environment OR education OR high-fidelity OR interprofessional)) OR ((role) W/1 (playing)) OR ((interact* OR simulat*) W/2 (learning)) OR ((standardi*) W/1 (patient))) AND TITLE-ABS-KEY ((pharmacy OR pharmaceutic*) W/2 (student OR educa-tion)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re"))
ERIC <1965 to January 2022> - Search strategy
1 pharmaceutical education/
2 ((pharmacy or pharmaceutic*) adj3 (student* or education)).mp.
3 1 or 2
4 Simulation/
5 Role Playing/
6 Simulated Environment/
7 (simulat* adj3 (training* or patient* or environment or education or high-fidelity or interprofession-al)).mp.
8 (role adj1 playing*).mp.
9 ((interact* or simulat*) adj3 learning).mp.
10 (standardi* adj1 patient*).mp.
11 4 or 5 or 6 or 7 or 8 or 9 or 10
12 3 and 11

Figure 1: Supplementary material

Eligibility criteria

The eligibility criteria (inclusion and exclusion criteria) are presented in Table I. Articles published before 2000 were excluded. Incorrect intervention types encompassed literature reviews, descriptions of educational programmes, workshops, or patient cases without interaction, assessment, or examination were also rejected.

Table I: Eligibility criteria (inclusion and exclusion criteria) of references to be included in the scoping review

	Inclusion criteria	Exclusion criteria
Population	• Students in pharmacy programme • Interprofessional collaboration with pharmacy students and other disciplines	• Wrong population (professional pharmacists) • Students in pharmacy were playing a minor role.
Intervention	Simulation training	• Inappropriate settings/intervention: Simulation training focusing on the evaluation/assessment of the performance: certification assessments or examinations, objective structured clinical exam (OSCE) • Insufficient description of the simulation activity • Insufficient pharmacy student's participation in interprofessional collaboration • Post-graduate pharmacy activities
Concept	Face-to-face or in-person (by telephone or face-to-face) simulation training	• Virtual simulation training, online simulations
Context	French and English	• Pharmacy dispensary
Sources	Peer-reviewed original studies	• Records • Short commentaries • Conference abstracts • Book reviews • Letters to editors

Selection of studies and data extraction

Titles and abstracts were independently screened by two authors; Aurore Gaspar (AG) and Geneviève Philippe (GP), to exclude records that did not match the eligibility criteria. Marjorie Bardiau (MB) acted as the third peer to arbitrate in the event of a difference of opinion. The full text of each selected article was screened to determine whether it met the eligibility criteria. The data extraction of the selected papers was conducted using a pre-defined data sheet developed by the authors.

Results

Study selection

In total, 812 articles were identified from the database searches after duplicates had been removed. In fact, 397 of the original 812 screened, using the titles and abstracts, were considered eligible for full-text screening. Following full-text screening, 140 studies were selected for the scoping review. Figure 2 shows the PRISMA flow chart describing the process of selecting articles.

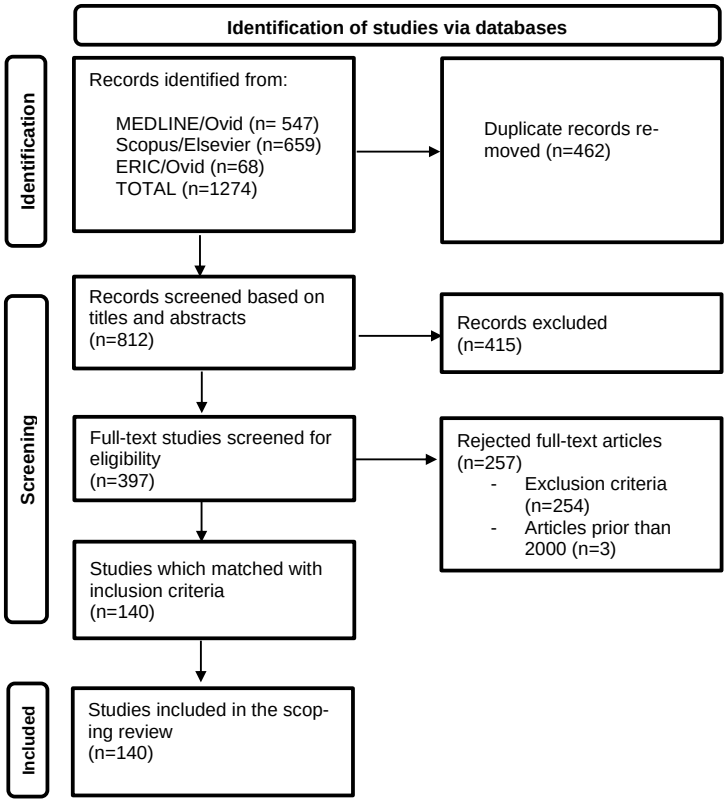

Figure 2: PRISMA flow diagram for the inclusion of articles on simulation training for students in pharmacy until February 2022

General characteristics of included studies

Appendix A shows the characteristics of accepted studies (extraction table).

The majority of the selected studies were single-site studies, with many having been conducted in the United States (n=107), Australia (n=12) and England (n=9). Other countries represented to a lesser degree were Canada, China, Ireland, Japan, Jordan, Korea, New Zealand, Qatar, Saudi Arabia, Scotland, Spain, and Turkey. The most common designs were pre-post surveys, post-activity assessments, and mixed-method studies. Other study designs, found to a lesser degree, included comparative, observational, cohort, and correlation studies.

Simulation modalities

Two simulation modalities, SiP modality and HM, were used for in-person training scenarios.

SiP modality represented 62 articles of the 140 selected (44%). Pharmacy students took the role of a pharmacist and worked with a person assuming the role of a patient. The SiP modality can be further subdivided into standardised patients (SP) and simulated patients in a

role-play (RP). SPs followed a predefined script, while SiP, in a role-play, was given free rein to improvise a dialogue that met their patients' needs (Chiniara *et al*., 2013). SPs and RPs each represented 50% of the SiP modality. In a small number of studies, SiP referred to real patients (Basheti, 2014; Boukouvalas *et al*., 2018; Barrickman *et al*., 2020; Wang *et al*., 2020). Hybrid modality represented 56% of the selected studies (78 articles out of the total 140). Pharmacy students acted as pharmacists in an IPR that integrated multiple simulation modalities for patient care provision (Chiniara *et al*., 2013). Simulation modalities which accompanied IPR were SPs, RPs, human simulators (high-fidelity or low-fidelity mannequins) (Jung *et al*., 2020) (Marken *et al*., 2010), SCI (Chiniara *et al*., 2013) or a patient case. Therefore, the patient was not necessarily someone playing a role, but there was interaction between two (or more) healthcare professionals.

Impact of simulation training on pharmacy student's non-technical skills

Simulation training has been shown to have a positive impact on the education of pharmacy students in 3 main areas: (1) patient communication (PC), (2) medication counselling (MC) and (3) interprofessional education (IPE) skills.

Table II shows the impact of simulation training on non-technical skills.

Table II: Simulation training's impact on non-technical skills

Reference	Simulation training's impact			Type of impact (+, -, 0)	Description of impact measured
	PC	MC	IPE		
Acquavita, 2021			P	+	IPE using SBIRT, knowledge, perceived competence, frequency of care
Baalmann, 2022			P	+	IPE confidence in error disclosure, telehealth technology
Bajis, 2021		P		+	knowledge and confidence in asthma first aid performance and counselling
Bajis, 2019		P		+	medication reconciliation skills, self-perceived confidence, and satisfaction
Barker, 2018	P			+	self-reported generic communication competencies, confidence
Barrickman, 2020		P		+	MTM, patient care skills in acute care setting
Bartlett, 2020			P	+	IPE (IP communication, role-related knowledge and skills, confidence, and satisfaction)
Basheti, 2014		P		+	MC in verbal and clinical device technique education
Begley, 2013		P		+	MTM (medication-related problems, drug utilisation reviews, prescription verification and patient counselling)
Begley, 2019			P	+	IPE (IPC, team skills and team performance linked to IPEC core competencies)
Bottenberg, 2013			P	+	IPE perceptions and attitudes toward IP collaboration
Boukouvalas, 2018	P			+	PC (attitude towards suicidal crises)
Bowers, 2021			P	+	IPE perceptions, knowledge retention, IP care plan development
Bowers, 2017		P		+	MC (insulin injection technique, counselling skills, knowledge retention)
Brennan, 2021			P	+	IPE (perceptions of IPC, teamwork, communication, RR, patient outcomes from collaborative practice)
Brock, 2013			P	+	IPE (attitudes toward team communication, motivation, knowledge, IP communication)
Candelario, 2019		P		+	MC (TOC education)
Chen, 2015	P			+	PC (empathy, perceptions, attitude toward elderly patients)
Chen, 2011	P			+	PC (perceptions of attitudes toward older adults, understanding of patient experience)
Chen, 2008	P			+	PC (empathy, care of underserved patients)
Chen, 2015	P			+	PC (confidence in providing patient counselling)
Christopher, 2019			P	+	IPE (attitude toward collaboration and teamwork, RR)
Clauser, 2020			P	+	IPE (perceptions of physician-pharmacist IP clinical education)
Cobb, 2019	P			+	PC (communication skills, empathy, and confidence)
Cooke, 2017			P	+	IPE (attitude toward collaborative practice)
Cowart, 2021		P		+	MC (confidence in performing manual blood pressure technique, communication skills, drug information)

Reference	Simulation training's impact			Type of impact (+, -, 0)	Description of impact measured
	PC	MC	IPE		
Crowl, 2021			P	+	IPE (value of IP simulation, confidence)
Curley, 2019			P	+	IPE (assertiveness and confidence in team environments, assessment of patients, knowledge, IP communication)
Curran, 2005		P	P	+	IPE (role perception, IPC, self-reported teamwork, confidence), MTM (to develop an IP care plan for simulated HIV/AIDS patients), satisfaction
Davies, 2015		P	P	+	IPE (performance and confidence in physician communication), MTM (patient education, therapy communication and assessment skills)
Draime, 2020		P		+	PC (HIV treatment knowledge), TBL
Efstathiou, 2013			P	+	IPE (self-perceived improvements in knowledge, skills, confidence, competence in end-of-life care communication)
Egelund, 2020			P	+	IPE (communication, teamwork)
El-Den, 2018	P			0	PC in Mental Health First Aid (confidence, performance)
Estes, 2016			P	+	IPE (collaboration, telehealth communication)
Eukel, 2021	P			+	PC communication abilities in difficult patient encounter and affective domain skills
Fejzic, 2015	P			+	PC (professionalism and practice skills application)
Fejzic, 2016	P			+	PC (professional communication skills)
Flores, 2018		P		+	MC (ability to assess skin disorders and to make recommendations), confidence and satisfaction
Frenzel, 2019			P	+	IPE (perceived competence in managing adult cardiac arrest, teamwork and collaboration, professional identity)
Fusco, 2020			P	+	IPE (self-reported competence toward IP collaboration, active participants, or observers)
Fusco, 2021			P	+	IPE (Interprofessional Socialisation)
Galal, 2012	P			+	PC (social and emotional competence)
Gallimore, 2008	P			+	preference for various types of simulated patients, MTM (clinical skill development)
Gillette, 2017	P			+	PC (pharmacist-patient communication compared to traditional active-learning activities)
Gough, 2013			P	+	IPE (perceptions of interprofessional learning and patient safety)
Grice, 2013	P			+	EI (patient relationship and communication skills using FHM)
Guadalupe, 2014		P		+	satisfaction, MC knowledge application
Gulpinar, 2021	P			+	patient-centered communication
Haddad, 2010	P			+	PC (emotions, communication in crisis situations, ethic dimension)
Hamilton, 2021			P	+	self-perception of IPE
Hannings, 2016		P		+	MC in mass dispensing and mass triage skills
Harris, 2018	P			+	EI (empathy and confidence in counselling on diabetes diet)
Hollamby, 2018			P	+	IPE (confidence, role understanding, awareness of patient safety issues)
Hussainy, 2012	P			+	PC (communication skills)
Isaacs, 2015	P			+	PC (perceptions of empathy and counselling skills)
Iverson, 2018			P	+	perceptions of IPE (teamwork, communication, RR)
James, 2001	P			+	PC (confidence, perceived ability to conduct an effective consultation)
Jebara, 2021			P	+	perceptions of IPE (collaboration, roles and responsibilities)
Joyal, 2015			P	+	IPE (knowledge, skills, attitude)
Jung, 2020			P	+	perceptions toward IPE, self-efficacy for IP experiential learning, perceptions toward IP competency
Karpa, 2019			P	+	IPE (knowledge and skills in geriatric assessment, roles and responsibilities, teamwork)
Kayyali, 2016			P	+	IPE (confidence, roles and responsibilities, IP communication and teamwork)
Kerr, 2021	P			+	communication training (effective communication between pharmacists and patients)
Kerr, 2015	P			+	PC (empathy when treating patients with diabetes, self-efficacy in diabetes management, counselling skills)

Reference	Simulation training's impact			Type of impact (+, -, 0)	Description of impact measured
	PC	MC	IPE		
Kiersma, 2009		P		+	MTM (knowledge and confidence in detecting, preventing, resolving, and communicating medication errors)
Komperda, 2019		P		+	MTM (perception of ability to perform medication reconciliation)
Koo, 2014			P	+	IPE (roles and responsibilities, confidence, teamwork)
Kostoff, 2016			P	+	IPE (perception of IP competence, attitude toward IP collaboration)
Kubota, 2018		P		+	IPE (perception of IP competence, attitude toward IP collaboration)
Kusnoor, 2019			P	+	IPE (collaborative problem solving, respect, shared accountability)
Lucas, 2020			P	+	IPE (IPC, role understanding, RR, team-based care)
Luiz, 2015	P			+	PC (oral and written communication)
Lynch, 2018		P		+	MTM (process of contraceptive prescription), satisfaction
Ma, 2020			P	+, (-)	(+) IPE (satisfaction with ability to work together) (-) satisfaction with distance technologies
MacDonnell, 2012			P	+	IPE (perceptions of IPC and teamwork)
MacDonnell, 2016			P	+	IPE perceptions of IP clinical experience (teamwork, communication, RR), knowledge and identification of domestic violence
Marken, 2010	P			+	PC (recognise and engage a difficult conversation with patient in an IP team)
Marshall, 2020			P	+	IPE (IPC, attitudes, competencies, and confidence in conducting team-based error disclosure)
Mathews, 2011	P			+	PC (cultural competency, communication with deaf and empathy toward all patients who have limited English language skills)
Miller, 2020	P	P		+	PC (chronic disease management, empathy), MTM (realization of an individualised medication)
Moote, 2019			P	+	IPE (values/ethics, roles and responsibilities, IP communication)
Motycka, 2018			P	+	IPE (attitudes toward teamwork and MTM to prevent medication errors)
Nestel, 2007		P		+	MC (medication counselling training), satisfaction with experience
Norville, 2021		P		+	MC (knowledge, self-confidence in the pharmaceutical care for patient with cancer)
Ottis, 2016		P	P	+	IPE (IPC, RR), MTM (patient safety in acute pain management, drug-related problems identification)
Patel, 2018		P		+	MTM (knowledge, confidence, and patient counselling skills on clinical pharmacogenetics)
Paterson, 2015			P	+	IPE perceptions, attitudes toward IP collaboration, confidence
Planas, 2008	P			+	EI (empathy, patient communication)
Popkess, 2017			P	+	IPE (attitude toward errors disclosure)
Powers, 2019		P		+	MTM (knowledge, confidence, and patient counselling skills on clinical pharmacogenetics)
Quesnelle, 2018			P	+	IPE (communication, IPC, RR, teamwork), PGx confidence
Ragucci, 2014			P	+	IPE perception on professional development
Ragucci, 2016			P	+	IPE (confidence, satisfaction IP communication, team disclosing error to patient)
Rao, 2011	P			+	PC (patient-care skills in communication and information gathering)
Ray, 2018		P		+	MTM (computer use skills, pharmacotherapy plan counselling), retention into next professional year, confidence
Ray, 2017		P		+	MC (ability to incorporate computers into patient medication counselling)
Rickles, 2009	P			+	PC (communication skills)
Rivera, 2018			P	+	IPE (IPC, communication skills, teamwork, team-based practice)
Sales, 2013	P			+	PC (cultural competency: cultural skills and cultural desire component)
Schultz, 2007	P			+	PC (patient centered care, clinical skills)
Schwindt, 2018			P	+	IPE (perceived self-efficacy and self-reported counselling abilities, IPC skills)
Seghal, 2019			P	+	IPE (awareness of interprofessional values/ethics, roles/responsibilities, communication, and teamwork)
Serag-Bolos, 2018		P		+	MC oncology-related knowledge, confidence, and perceived understanding of the roles of oncology pharmacists

Reference	Simulation training's impact			Type of impact (+, -, 0)	Description of impact measured
	PC	MC	IPE		
Serag-Bolos, 2017		P		+	TOC (perceptions and knowledge of pharmacist roles in TOC)
Shaikh, 2020			P	+	IPE self-perceived IPC (teamwork and collaboration skills)
Sharder, 2015			P	+	IPE (attitude toward IPC, confidence in IP communication skills)
Sharder, 2014			P	+	IPE (perceived competence in IP collaboration)
Sharder, 2013			P	+	IPE teamwork scores on clinical outcomes in a simulated healthcare environment
Sharder, 2016			P	+	IPE (attitude toward health care team with various methods of communication, perception of communication technologies to enhance collaboration)
Sharder, 2011			P	+	IPE (attitude in IP teamwork, satisfaction)
Sincak, 2017			P	+	IPE (IPC, knowledge, skills, attitude, self-perceived behaviours, and patient care)
Singla, 2004		P	P	+	IPE (attitude toward IPE through), MTM (medication adherence skills)
Smith, 2019			P	0	IPE (IPC, RR, profession knowledge of either profession)
Smith, 2020			P	0	IPE (IPC, RR)
Smithburger, 2013			P	+	IPE (communication and teamwork)
Southall, 2021			P	+	IPE (attitude toward collaboration and teamwork, RR)
Stehlik, 2018			P	+	IPE (attitude toward IPC)
Stewart, 2013		P		+	confidence in knowledge and application of legal concepts
Suematsu, 2018			P	+/-	IPE (perceived competence in IP collaboration)
Suematsu, 2021			P	+	satisfaction of online IPE (IPC)
Tallentire, 2021			P	+	transformative learning (students' IPE behaviours and relationships)
Terriff, 2017		P		+	MC (interest, comfort, and confidence in ability to administer a paediatric vaccination)
Thakur, 2020		P		0	MC, EI (communication in a consultation with LEP patient about opioid)
Thomas, 2021			P	+	IPE (communication skills, roles and responsibilities, caring patients at the end of life)
Tilley, 2021			P	+	IPE (communication, collaboration, roles and responsibilities, collaborative patient/family approach, conflict resolution and team functioning)
Tremblay, 2018			P	+	IPE (satisfaction and perception of a CRM simulation)
Tremblay, 2017	P			+	PC (perception of learning and emotions with SP versus SCI)
Tremblay, 2019	P	P		+	PC (cognitive load), MTM (task performance) and perception of learning SCI
Ulutaş Deniz, 2018		P		+	satisfaction (EI communication skills and MTM knowledge application)
Victor-Chmil, 2016			P	+	IPE perceptions (problem resolution, IPC, IP communication in learning and reporting about child abuse)
Vyas, 2012		P		+	MC (perception of preparedness before APPE, knowledge, APPE abilities)
Vyas, 2018	P	P		+	PC, MC (knowledge, attitudes, and ability to address vaccine hesitancy/refusal)
Vyas, 2012		P	P	+	MC (knowledge, attitude, skills in patient safety), IPE (IPC, teamwork, communication skills)
Wagner, 2021		P		+	knowledge and confidence in MTM (medication reconciliation and discharge counselling)
Wang, 2020			P	+	IPE (IPC, RR)
Wen, 2019			P	+	IPE (IP core competencies)
Westberg, 2006			P	+	IPE (satisfaction, knowledge of the roles of other professions)
Willson, 2020	P			+	PC in suicide prevention and communication (knowledge, confidence and skills in suicide prevention and counselling individuals considering suicide)
Wong, 2021			P	+	IPE (communication, collaboration, roles and responsibilities, collaborative patient/family approach, conflict resolution and team functioning)

Patient communication

The definition of communication used for this paper is the ability to communicate with patients, using effective verbal and nonverbal communication, considering patient's beliefs and attitudes, and delivering relevant information (Tindall *et al*., 1990; Kimberlin, 2006; Mafinejad *et al*., 2017). In this study,

the term 'patient communication' includes emotional areas and skills such as empathy, social competency, and attitude. PC was assessed and was seen to be present in 26% of the selected studies (37 papers). Simulation training was found to have had a positive impact on this in all but one of the articles.

Type of cases

The cases included chronic role-reversal simulation (in which each student took the role of a pharmacist and/or a patient) (Chen *et al*., 2015a). Sensitive and difficult patient topics of conversation (Westberg *et al*., 2006; Schultz & Marks, 2007; Marken *et al*., 2010; Eukel *et al*., 2021) included: suicide risk (Boukouvalas *et al*., 2018; El-Den *et al*., 2018; Willson *et al*., 2020), cancer (Serag-Bolos *et al*., 2018), vaccination (Vyas *et al*., 2018), risk of opioid abuse (Thakur *et al*., 2019), teratogenic drugs (Haddad, 2010), pregnancy, erectile dysfunction (Kerr *et al*., 2021b), pharmacogenetics (Powers *et al*., 2019), and end of life palliative care (Efstathiou & Walker, 2014; Thomas *et al*., 2021). The skills worked on included social competencies, attitude toward elderly patients, cultural competence, assertiveness (Luiz Adrian *et al*., 2015), leadership, verbal and non-verbal behaviour (Barker *et al*., 2018), communication skills (Rickles *et al*., 2009), social competence (Galal *et al*., 2012), empathy and holistic care (Gülpınar & Özçelikay, 2021; Thomas *et al*., 2021).

Assessment of the impact of simulation training on patient communication

PC competencies were assessed using different tools. These were Communication Skills Assessment Form (CSAF) (Rickles *et al*., 2009), the Social Emotional Development Inventory (SED-I) (Galal *et al*., 2012), the Four Habit Model (FHM) (Grice *et al*., 2013a) and the patient-centred communication tool (PaCT) (Gülpınar & Özçelikay, 2021).

Medication counselling

MC included knowledge application, medication therapy management (MTM) and transition of care (TOC), which referred to patients moving from one healthcare setting to another. This involved a team which included the patient, multiple providers, and family or social support (Serag-Bolos *et al*., 2017). MC was studied in 28% of the studies selected (39 papers), and simulation training was said to have been beneficial in 38 studies.

Type of cases

The scenarios in the studies used for MC training purposes included patient counselling (i.e. use of effective interview sequence and structure during interactions), medication reconciliation, medication review and management, and error disclosure (Shrader *et al*., 2011; Ragucci *et al*., 2016), vaccination, device technique demonstration, drug-induced skin reactions, sepsis management, first aid for asthma, pharmaceutical care for patients with cancer (Serag-Bolos *et al*., 2018; Fusco *et al*., 2021; Norville *et al*., 2023), clinical pharmacogenetics (Patel *et al*., 2018; Powers *et al*., 2019), diabetes management, contraceptive counselling or pharmacogenetics (Lynch *et al*., 2018; Patel *et al*., 2018).

Assessment of the impact of simulation training on medication counselling

Students' knowledge, confidence and medication counselling skills were assessed using evaluation forms, marking scales, objective structured clinical examination (OSCE), a checklist, pre-post surveys and knowledge scales.

Interprofessional education (IPE)

In total, 53% of the selected studies focused on IPE. Simulation training was seen to have had a positive impact on different domains of IPE core competencies in 71 of the identified articles.

Type of cases

A number of different IPE core competencies were included in the simulation scenarios, including interprofessional communication and telehealth, interprofessional collaboration (IPC) and team functioning (Estes *et al*., 2016; Quesnelle *et al*., 2018; Begley *et al*., 2019; Wong *et al*., 2021; Baalmann *et al*., 2023), roles and responsibilities (RR) and professional identity, collaborative patient/family, conflict resolution and error disclosure (Kusnoor *et al*., 2019; Baalmann *et al*., 2023). The skills worked on included medication dispensing, drug dependence, care of older adults, crisis resource management (CRM), and pneumonia patients (Bottenberg *et al*., 2013; Fejzic & Barker, 2015; MacDonnell *et al*., 2016; Cooke *et al*., 2017; Tremblay, 2018; Schwindt *et al*., 2019; Fusco & Foltz-Ramos, 2020; Tilley *et al*., 2021). The cases were used to develop student's confidence, self-perceived value, knowledge retention, patient safety/care (Suematsu *et al*., 2018), TOC (Shrader & Griggs, 2014; Ragucci *et al*., 2016; Sen *et al*., 2016; Shrader *et al*., 2016; Stehlik *et al*., 2018; Frenzel *et al*., 2019; Meny *et al*., 2019; Wen *et al*., 2019; Fusco & Foltz-Ramos, 2020; Smith, 2020), discharge counselling, polypharmacy and acute pain management (Ottis & Gregory, 2016; Sehgal *et al*., 2019). The IP teams that were most frequently observed brought together medical, nurse and pharmacy students (54% of the IPE articles).

The SBAR (Situation, Background, Assessment, Recommendation) communication tool was the most

popular for improving self-perception of interprofessional competence and attitude toward interprofessional collaboration (in 9 articles) (Koo *et al*., 2014; Shrader *et al*., 2015; Shrader *et al*., 2016; Ottis & Gregory, 2016; Iverson *et al*., 2018; Patel *et al*., 2018; Curley *et al*., 2019; Cowart & Updike, 2021). The SBIRT (Screening, Brief Intervention and Referral to Treatment) tool helped students collaborate to identify potential medication misuses (Marken *et al*., 2010; MacDonnell *et al*., 2016; Clauser *et al*., 2020; Egelund *et al*., 2020; Acquavita *et al*., 2021).

Assessment of the impact of simulation training on interprofessional education

IPE was measured with validated tools in 28 studies. The following scales were used to measure a number of aspects of IPE: The Readiness for Interprofessional Learning Scale (RIPLS) was the most frequently applied scale as it measured changes in attitude toward teamwork and IPC, knowledge of roles and responsibilities of healthcare team members (Bottenberg *et al*., 2013; Gough *et al*., 2013; Efstathiou & Walker, 2014; Paterson *et al*., 2015; Christopher *et al*., 2019; Frenzel *et al*., 2019; Wang *et al*., 2020; Southall & MacDonald, 2021). Other assessment scales used were JEFFSATIC (Jefferson Scale of Attitudes Toward Interprofessional Collaboration) and ATHCTS (Attitude Toward Health Care Teams Scale) (Shrader *et al*., 2016; Smith *et al*., 2019; Smith, 2020), SPICE-R (Students Perceptions of Interprofessional Education Revised) (MacDonnell *et al*., 2016; Iverson *et al*., 2018; Clauser *et al*., 2020; Brennan *et al*., 2021), ICCAS (Interprofessional Collaborative Competencies Attainment Survey) (Kostoff *et al*., 2016; Wen *et al*., 2019; Fusco & Foltz-Ramos, 2020; Wong *et al*., 2021); C-ICE (Creighton Interprofessional Collaborative Evaluation), CATS (Frankel's Communication and Teamwork Skills assessment) (Smithburger *et al*., 2013; Begley *et al*., 2019; Egelund *et al*., 2020), Interprofessional Attitudes Scale (IPAS) (Marshall *et al*., 2020), RR quiz (Kusnoor *et al*., 2019; Smith *et al*., 2019; Hamilton *et al*., 2021; Suematsu *et al*., 2021) and TSS (Team Skill Scale)(Begley *et al*., 2019).

Gaps

Gaps shown by the assessment of the simulations' effectiveness

The main gap that was observed was a lack of objective measures or validated evaluation tools, especially for the assessment of emotional skills (Galal *et al*., 2012; Chen *et al*., 2015a; Isaacs *et al*., 2015; Cobb *et al*., 2019).

The absence of a control group from data before and after a survey meant there was a risk of participant bias in the simulation experience (Bottenberg *et al*., 2013; Paterson *et al*., 2015; Ottis & Gregory, 2016; Cobb *et al*., 2019; Curley *et al*., 2019; Meny *et al*., 2019; Brennan *et al*., 2021). Some studies had limitations in their methodology, mainly due to lack of time, personnel and resources (Westberg *et al*., 2006; Marken *et al*., 2010; Sales *et al*., 2013; Guadalupe, 2014). A common limitation in the studies included in the review was that the sample size was often small, consisting of only one cohort or academic year. In a few cases, the opposite was true and the sample size was too big, which may have hindered the effectiveness of the simulation. Additionally, there was a risk of student selection bias and response bias, which may have influenced the results. Social desirability bias was also a concern, as well as the potential for social acceptance bias in some studies. Simulation debriefing is a critical component of IPE (Meny *et al*., 2019), but many studies lacked feedback/debriefing sessions (Nestel *et al*., 2007; Chen *et al*., 2015b; Shrader *et al*., 2016; Gillette *et al*., 2017; Rivera *et al*., 2018; Gülpınar & Özçelikay, 2021). Most of the studies had not been measured quantitatively but were based on self-assessment or self-perception measures rather than changes in behaviour (Harris *et al*., 2018).

Specific gaps in SiP modality

The amalgam in the literature of "*simulated patient*" and "*standardised patient*" was also seen to be present in the analysis of the results. These concepts are not always clear and the terminology used in the context of the simulated and standardised patient is prone to confusion (Burnier *et al*., 2019).

Language barriers, cost, differences between the different SiP in one activity, lack of experience with sensitive topics, complexity and realism of scenarios could be said to limit the transferability of potential learning in the real world (Grice *et al*., 2013b; Chen *et al*., 2015b; Hannings *et al*., 2016; Ray & Valdovinos, 2017; Terriff & McKeirnan, 2017; Flores & Hess, 2018; Kubota *et al*., 2018; Bajis *et al*., 2019; Cobb *et al*., 2019; Thakur *et al*., 2019; Willson *et al*., 2020; Bajis *et al*., 2021; Kerr *et al*., 2021a).

Specific gaps in hybrid modality

There were a number of validated tools available to measure IPE competencies but they were not systematically used and were sometimes adapted to meet specific simulation needs or the needs of a particular curriculum (MacDonnell *et al*., 2012; Ottis & Gregory, 2016; Quesnelle *et al*., 2018; Suematsu *et al*., 2018; Wen *et al*., 2019; Egelund *et al*., 2020). The influence of one profession on another was sometimes difficult to measure due to the use of post-surveys only

being performed immediately after the simulation (Gough *et al*., 2013; Ottis & Gregory, 2016; Smith *et al*., 2019; Crowl *et al*., 2021; Bowers *et al*., 2022). The use of students from different professional programmes has sometimes resulted in participants with differing levels of clinical experience. However, the absence of control over earlier experiments carried out by team members, such as using a human simulator, or an unequal distribution of students from each profession due to smaller class sizes, may have had an impact on the results. Moreover, some studies indicate that the full range of professions is not equally represented in interprofessional teams, creating an imbalance and potential selection bias, even causing some students to feel frustrated or underprepared. Additionally, there is a need for standardisation of simulation scripts, with equal participation time for each profession during the simulation. Students may also lack knowledge in certain areas, such as tobacco addiction, which can lead to discomfort during simulations (Shrader *et al*., 2011; Vyas *et al*., 2012; Bottenberg *et al*., 2013; Ragucci *et al*., 2016; Victor-Chmil & Foote, 2016; Iverson *et al*., 2018; Curley *et al*., 2019; Frenzel *et al*., 2019; Schwindt *et al*., 2019; Clauser *et al*., 2020; Egelund *et al*., 2020; Shaikh *et al*., 2020; Bowers *et al*., 2022).

In rural areas, technological frustrations or difficulties sometimes outweighed the benefits of the proposed videoconferencing option. Satisfaction with distance technology was subsequently lower in a small number of studies compared with the satisfaction of students who participated face-to-face (Wen *et al*., 2019; Clauser *et al*., 2020; Ma *et al*., 2020).

Discussion

This exploratory and reproducible study mapped simulation activities aimed at pharmacy students and could add to the existing literature the main fields of application commonly used and the challenges encountered in implementing this type of activity.

Implication of simulation training in SiP modality

Simulation training is a way of enhancing pharmacy practice experience when direct student-patient interactions are limited (Wagner *et al*., 2021). Results showed it can be a useful tool for developing essential patient-care skills including information gathering, developing a patient care plan (Rivera *et al*., 2018), discharge counselling (Planas & Er, 2008; Kiersma *et al*., 2009; Komperda & Lempicki, 2019; Wagner *et al*., 2021), medication reconciliation knowledge (American College of Clinical Pharmacy *et al*., 2012; Sen *et al*., 2016; Serag-Bolos *et al*., 2017), and to be aware of the pharmacist's role during emergency situations (Hannings *et al*., 2016; Terriff & McKeirnan, 2017).

The simulation methodology helped students put theory into practice and recognise the challenges of effective communication (James *et al*., 2001; Planas & Er, 2008; Rao, 2011; Guadalupe, 2014; Ray & Valdovinos, 2017; Ray *et al*., 2018). Role-reversal chronic disease simulation provided an approach to foster communication and patient care, empathy and comfort in the interaction with patients (Mathews *et al*., 2011; Isaacs *et al*., 2015; Kerr *et al*., 2015; Harris *et al*., 2018; Miller *et al*., 2020). During simulations, some students did not communicate in their native language (i.e. English) (Bajis *et al*., 2019; Bajis *et al*., 2021). Adapting the communication of the pharmacist (as well as the physician) based on the patient's cultural context, linguistic abilities, and intellectual quotient (IQ) represents a crucial area for improvement in simulation-based training at a time when many areas are cosmopolitan in character.

Implications of simulation training in HM

The number of publications on IPE has underlined the importance of health professionals' collaboration and guiding institutions in developing educational programmes (Suematsu *et al*., 2018). In some countries, IPE is not well known, which could be said to be another gap that needs to be filled (Smithburger *et al*., 2013; Shrader & Griggs, 2014; Kayyali *et al*., 2019; Egelund *et al*., 2020; Jung *et al*., 2020).

In TOC, simulations helped students to understand the extent to which pharmacists play a vital role in ensuring continuity of care as part of a team consisting of different healthcare professionals (Serag-Bolos *et al*., 2017). Students improved self-reported IPC (Shrader & Griggs, 2014; Ragucci *et al*., 2016; Sen *et al*., 2016; Shrader *et al*., 2016; Stehlik *et al*., 2018; Frenzel *et al*., 2019; Meny *et al*., 2019; Wen *et al*., 2019; Fusco & Foltz-Ramos, 2020; Smith, 2020), believed themselves to be more competent, trusted the opinion of their colleagues (Bottenberg *et al*., 2013; Fejzic & Barker, 2015; MacDonnell *et al*., 2016; Cooke *et al*., 2017; Tremblay, 2018; Schwindt *et al*., 2019; Fusco & Foltz-Ramos, 2020; Tilley *et al*., 2021) and developed a positive attitude toward teamwork, which they believed to be crucial for improving patient safety (Popkess *et al*., 2017; Iverson *et al*., 2018; Motycka *et al*., 2018).

Despite some technological difficulties (Wen *et al*., 2019; Clauser *et al*., 2020; Ma *et al*., 2020), communication technologies had positive impacts on students and taught them a lot about approach, confidence, performance related to interprofessional communication, collaboration, and the development of

an interprofessional care plan (Shrader *et al*., 2016). Telephone conversations were considered by authors to be a creative way of breaking down barriers of location, cost, scheduling, and lack of access to healthcare professions (Moote *et al*., 2019). Some barriers to interprofessional education were eliminated thanks to a telehealth simulation, particularly during the Covid-19 pandemic. In this way, the telehealth simulation was able to improve the student's confidence in the use of these technologies (Estes *et al*., 2016; Begley *et al*., 2019; Wen *et al*., 2019; Ma *et al*., 2020; Cowart & Updike, 2021; Wong *et al*., 2021; Baalmann *et al*., 2023). Incorporating telehealth-learning into a curriculum may give students an opportunity to be better prepared to practice in the ever-evolving healthcare environment (Estes *et al*., 2016). However, further research is still needed to compare the effectiveness of online IPE learning with traditional face-to-face IPE (Suematsu *et al*., 2021). The results of this review showed simulation training is one way to practice IPE and it is recognised the world over as a key concept in initiatives aimed at improving the efficiency of health services currently offered to the population and improving the quality of delivered health care.

Insights for future research

Addressing the gaps seen in simulation assessment

To more effectively assess the impact of skills learned by simulation training, more stringent assessment measures should be developed and could include a well-designed randomised controlled trial with clear outcomes. Gaps discovered in education highlighted the need for more robust evaluation measures and standardisation of simulation scripts to improve the quality and effectiveness of interprofessional simulation-based education (Haddad, 2010; Gough *et al*., 2013; Chen *et al*., 2015a; Fejzic *et al*., 2016; Terriff & McKeirnan, 2017; Pawluk *et al*., 2018; Serag-Bolos *et al*., 2018; Cobb *et al*., 2019; Kusnoor *et al*., 2019; Korayem & Alboghdadly, 2020; Eukel *et al*., 2021). Transferability (as long-term gains in knowledge and skills and changes in behaviour after a simulation) should, in practice, be assessed (Mesquita *et al*., 2010; Chen *et al*., 2011; Chen *et al*., 2015a; Bowers *et al*., 2017; Pawluk *et al*., 2018; Tremblay, 2018; Vyas *et al*., 2018; Komperda & Lempicki, 2019; Wang *et al*., 2020; Gülpınar & Özçelikay, 2021; Bowers *et al*., 2022). However, the fact that assessing emotional intelligence skills can be complicated and even, in some cases, inappropriate should be considered.

Addressing the SiP modality gaps

The international literature makes a clear distinction between simulated and standardised patients, but there is still a need for a clear definition of these concepts. By clarifying them, this exploratory review guarantees the reproducibility of the research, enabling the classification of articles that used the rather vague term simulated patient. For example, the presence of a written scenario in the full-text description of an activity made it possible to verify whether it was an SP or a SiP taking part in a role-playing game.

The involvement of simulated patients when giving feedback is important for training in person-centred care (Paterson *et al*., 2015; Sincak *et al*., 2017). Various approaches could be considered to address the limitations encountered with simulated patients: replacing actors with students to keep costs to a minimum (Hollamby *et al*., 2018; Thomason *et al*., 2018), involving non-pharmacy students (faculty administrative staff) (Schultz & Marks, 2007; Gallimore *et al*., 2008), and involving drama students to enhance the authenticity of simulations (Fejzic *et al*., 2016). However, it is important to note that using healthcare providers as simulated patients also reduces the possibility of findings making their way to the wider public (Singla *et al*., 2004). Similarly, storyline details need to be organised to ensure consistency or level of complexity (Chen *et al*., 2015b; Hannings *et al*., 2016; Kubota *et al*., 2018).

Inconsistencies exist regarding the involvement of real patients in training healthcare professionals (Basheti, 2014; Boukouvalas *et al*., 2018; Barrickman *et al*., 2020; Wang *et al*., 2020; Christopher *et al*., 2021). Therefore, further investigation is needed to explore the relationship between different types of simulated patients and students' results (Gallimore *et al*., 2008).

Adaptations to the level of the learners

Outcomes of communication education interventions are influenced by the level of the learner. Intervention choice, based on the level of learning, is important (Kerr *et al*., 2021a). There is a need for the development of adapted guidelines in simulation for novices (Westberg *et al*., 2006; Vyas *et al*., 2012; Karpa *et al*., 2019). SCI was reported as being more cognitively demanding than using SiP (Tremblay *et al*., 2017; Tremblay *et al*., 2019). Repeated simulations, at different times during the term, provided multiple opportunities for students to conduct simulated pharmacy practice activities and reinforce performance, skills development and knowledge retention (Rickles *et al*., 2009; Begley *et al*., 2013). Tailoring a patient activity to the students'

needs, especially for students with a lower level of communication (including those who had to communicate in a language that was not their mother tongue), is paramount if they are to fully develop and retain communication skills (Grice *et al*., 2013a; Cobb *et al*., 2019; Kerr *et al*., 2021b). However, it is also necessary to develop education regarding the discussion of sensitive topics, as students found these more demanding and were embarrassed and reluctant to discuss them during the activity (Bajis *et al*., 2019; Thakur *et al*., 2019).

Strengths and limitations

There may be several elements of the design of this research that create uncertainty regarding the contribution of the knowledge gained. Indeed, the exhaustive nature of the research and the inclusion criteria resulted in a large amount of data needing to be classified. There is a great heterogenicity of the intervention methods and tools to evaluate the impact of simulation training. Another classification gap for "*simulated patients*" was revealed. In the same way as in the literature on the subject, this results from confusion about the terms used (simulated patients, standardised patients). Although a definition for each term was given, the reproducibility of this study may be impacted.

The review follows the PRISMA criteria, but there was no double reading of the full texts (full texts were only read by the first author, AG). These uncertainties could, therefore, have an impact on the relevance of the work, mainly in terms of reproducibility. Finally, in terms of quality, a quality assessment such as the Medical Education Research Study Quality Instrument (MERSQI) could have been conducted.

Almost all the studies considered in this review have been conducted in countries with Anglo-Saxon cultural, intellectual, and/or educational backgrounds, which may not necessarily be globally representative. The patient populations targeted in each country do not have equal access to healthcare and medication. As a future area to focus on, studies should aim to reach the standard set by the Kirckpatrick/Barr learning outcomes models, including the improvement of patient outcomes (Sehgal *et al*., 2019; Marshall *et al*., 2020). Adapting the pharmacist's communication style and establishing a therapeutic alliance with each patient remains a significant challenge in the field of public health.

Conclusion

This study is an overview of on-site simulation training programmes currently available to pharmacy students. This paper focused on in-person simulations: SiP modality or IPR for the purpose of patient-centred care in a hybrid modality. Simulation training had a positive impact on student satisfaction, knowledge, and skills in various areas (emotional intelligence, medication counselling/knowledge application and IPE). This scoping review proposes alternatives and avenues of research to overcome the highlighted gaps. It provides insights for future research in the simulation area and could serve as a source of inspiration for countries that have still to adopt simulation practices. Thanks to this review, more effective simulation training programmes for pharmacy students, ultimately improving their preparedness and ability to provide high-quality care to their patients, may be created.

Conflict of interest

The authors declare no conflict of interest.

Source of funding

The authors did not receive any funding.

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Appendix A: General characteristics of the included studies (extraction table)

Reference	Title	Population	Settings	Assessment	Study design	Simulation modality	Type of simulator	Scenario design/activity description
Acquavita, 2021	Outcomes of an interprofessional SBIRT training program: Knowledge attainment and perceived competence for practice.	MS, NS, PS, and SWS (n=197)	Online coursework and interprofessional experiences. Students completed a minimum of 2 IP SBIRT experiences (screening, brief Intervention, referral to Treatment).	SBIRT knowledge, perceived competence, application of SBIRT knowledge and FOC (SMaRT, ATN-SBIRT), satisfaction (CSAT survey)	pre-post survey	H	IPR and SP	2 students from different disciplines implemented SBIRT with a SP. SBIRT aimed at addressing risky substance use by targeting the misuse of substances.
Baalmann, 2022	Interprofessional medication error disclosure training Utilizing a telehealth consultation simulation.	MS and PS (n=173)	IP telehealth simulation utilising Zoom in 3 phases: (1) individual student preparation; (2) IP telehealth consultation encounter for the error disclosure between the pharmacy and medical students; (3) IP debrief sessions.	confidence in error disclosure, use of health professionals, role of the community pharmacist (12-point rubric)	pre-post survey	H	IPR and patient chart	Telehealth consultation: pharmacy student and a medical student as the discharging hospital physician who was responsible for the patient's discharge MTM (rectification of discharge medication, medication errors identification and correction).
Bajis, 2021	Teaching asthma first aid to pharmacy students: A comparative study between an online course and simulation by role-play	3-, 4-, 5-year bachelor PS (n=50)	2-hour bimodal workshop: online training course and RP simulation on pharmacy students' ability to perform asthma first aid (AFA).	Preferred methods of learning were investigated by evaluation forms and focus group discussion (semi-structured survey)	comparative study	SiP	RP	Students in the simulation training group participated in a scenario-based interactive RP session. Patients in AFA scenarios experienced classic symptoms of acute asthma exacerbation. Immediate formative feedback and coaching were provided to the group of students by the facilitator after each role-play.
Bajis, 2019	Pharmacy students' medication history taking competency: Simulation and feedback learning intervention.	4 and 5-year PS (n=144)	3 days of simulation-based training activity. In-classroom and feedback-driven training activity.	medication reconciliation assessment (marking scale), self-perceived confidence questionnaire, focus group	mixed method, pre-post survey	SiP	RP	Scenario-based cases of patients on admission to hospital (simulated patient medication interview, reconcile the medication history against a hospital medication chart). Immediate feedback and focus group.
Barker, 2018	Simulated learning for generic communication competency development: A aase study of Australian post-graduate pharmacy students	Master of PS (MPharm, n=95)	4-h simulated learning modules (SLMs). 2 SLMs included Social Interaction Maps (SIMs) and involved interaction to learn generic social competencies.	survey before, during and after workshops (ECS), reflections from facilitators	mixed method, pre-post survey	SiP	RP	Commonly experienced pharmacy practice scenarios generated by pharmacists/pharmacy educators. Students developed their generic social competencies including participating in a team, refusing a request, and giving feedback.

Reference	Title	Population	Settings	Assessment	Study design	Simulation modality	Type of simulator	Scenario design/activity description
Barrickman, 2020	Development of coupled patient care experience courses to enhance patient care skills in the ambulatory and acute care settings.	3-year PS (n=104), 3-year MS and 4-year NS	Coupled patient care experience: 2 MTM simulation and a direct patient care activities outside of the normal class time, video recorded sessions.	Grading MTM acute care experience and students' feedback.	mixed method, post survey	H	IPR, patient chart, SP, real-life patient	IPE rounding simulation with medical and NS in randomly assigned groups. 2 patient charts to be established before the simulation. During the simulation, students work together as an IP team to assess both SPs and develop collaborative care plans before visiting a real patient (MTM).
Bartlett, 2020	Large-group, asynchronous, interprofessional simulation: Identifying roles and improving communication with student pharmacists and student nurses.	1-year NS (n=126) and 1-year PS (n=152)	Information regarding the simulation was provided to both groups of students separately following the IPE asynchronous simulation.	confidence, satisfaction (National League for Nursing Student Satisfaction and Self-Confidence in Learning instrument) and IP communication (feedback survey for pharmacy students)	(retrospective) pre-post survey	H	IPR and patient chart/case	Pharmacy student received, transcribed, filled a prescription that they received from nurses on voicemail lines (asynchronous IPR). Individual groups simulation debriefing occurred immediately following the simulation. A 25-min large-group, structured debriefing session occurred in the classroom, with both the nursing and pharmacy faculty.
Basheti, 2014	The effect of using simulation for training pharmacy students on correct device technique.	5-final year PS (n=99)	Students randomly assigned to 2 groups: intervention A (no simulation, n=54) and intervention B (simulation, n=55). Students' assessments on device technique repeated 1-week post-intervention. Focus group session for students from intervention B (n=15) 4 weeks following baseline.	device technique counselling assessment and focus group	single-blinded parallel group study, mixed method	SiP	RP	Real patient in RP. In group B, each student was randomly allocated to deliver education to a real patient using 1 of the 3 study devices proposed. Other students observed their peers delivering the patient education. The counselling involved verbal and physical demonstration until the patient performed all steps correctly.
Begley, 2013	Repeated testing to improve skills in a pharmacy practice laboratory course.	PS (814 students from 2008 to 2012, in average n=163)	Timed, repeated learning experiences (increasing complexity) for 5 years (cohort).	OSCE (10 stations) to measure performance (software programme for non-interactive tasks or faculty preceptors as SP for interactive stations)	cohort	SiP	SP	Scenarios standardised to contain the same type of information's and focused on management of various acute chronic diseases (drug utilisation review, advising a new medication, prescription verification). Consistent testing with evaluation and feedback.
Begley, 2019	Impact of interprofessional telehealth case activities on students' perceptions of their collaborative care abilities.	PS (1-, 2-, 3-, 4-year) and 2-year PAS; (n=172)	6 virtual rooms using telehealth technology for IP teams moderated by a pharmacy faculty member. Students' teams rotated through 6 rooms in 15 min sessions.	TSS and Creighton and Interprofessional Collaborative Evaluation (C-ICE) instrument, thematic analysis of students' reflections	mixed method, pre-post survey	H	IPR and RP	Telehealth IPR. Platform for distance-based participation in a real time IPE case study. "*Real-life*" experience to provide safe patient care (students joined virtual rooms, made recommendations, and received feedback on their performance).

Reference	Title	Population	Settings	Assessment	Study design	Simulation modality	Type of simulator	Scenario design/activity description
Bottenberg, 2013	Assessment of interprofessional perceptions and attitudes of health professional students in a simulation laboratory setting	2-and 3-year MS, 3- and 4-year PS, bachelor, and advanced degree NS, (n=163)	Mannequins exhibits human physiologic functions. 4 medical and 2 pharmacy students in each team with occasionally 2 NS. Following the simulation, students participate in a 30–60-minute discussion session with faculty from the different academic institutions.	24-item survey based on IPC, ATHCTS, RIPLS, and Interdisciplinary Education Perception scale	post activity assessment	H	IPR and manikin	IP students' teams performed simulated acute emergency room clinical situations on mannequins. Teams evaluate patient cases in the simulation lab for 20-30 minutes. The pharmacy students were responsible to provide drug information to team members on items such as dosages and adverse effects and to help identify and resolve drug-therapy problems.
Boukouvalas, 2018	Confidence and attitudes of pharmacy students towards suicidal crises: patient simulation using people with a lived experience.	final-year bachelor PS (BPharm, n=186) master PS (MPharm, n=66)	All students received a Mental Health First Aid training. Following MHFA training, group 1 directly participated in the simulation, group 2 observed, and group 3 had no exposure to the simulation.	ATTS	parallel group study, pre-post survey	SiP	SP	Real patients with a lived experience of mental illness acted as SiP experiencing a mental health crisis, including possible suicidal ideation. 3 different patient scenarios similar in nature were delivered (focus on mental health and symptoms of depression).
Bowers, 2021	Comparison of knowledge retention between case studies utilizing a simulated EHR with various degrees of simulated experiences.	1-year professional PS cohort 2018, 2019, 2021 (n=238), 1-year PAS	Each year an element of simulated experience was added into the previous case (simulated EHR): utilisation of the EHR (2018), OSCE with SPs (2019), interaction with student physician assistants (2021). Case scores and student perceptions were compared between groups.	OSCE, knowledge retention and student perceptions	prospective cohort study	H	IPR and SP	The SP acted as the patient described in the EHR. Additional information needed was collected from the SP to communicate the plan in IP interaction. Student pharmacists were randomly paired with 1 PA. PAs performed the physical examination and worked with the student pharmacists to develop a plan. After, students completed SP case.
Bowers, 2017	Impact of standardized simulated patients on first-year pharmacy students' knowledge retention of insulin injection technique and counseling skills.	1-year doctor PS (n=103)	A cluster of randomisations determined intervention group with simulated patients and control group without simulated patient. Intervention group received simulated SP interaction in addition to traditional coursework.	pre- and posttest scores to assess insulin injection, counselling skills and knowledge retention (yes/no format)	single-blind, single-cluster randomised study	SiP	SP	Students counselled the patient on correct insulin injection technique using an insulin vial and syringe. Students used the teach-back method with hands-on demonstrations until the patient was sufficiently trained in using their insulin.
Brennan, 2021	Improving health professions students' understanding of interprofessional roles through participation in a Patient stabilization simulation.	final year MS (n=41) and PS (n=17) and post-licensure nurses (n=22); (n=80)	Students worked together to stabilise a simulated acutely ill standardised patient, 10-min simulation.	SPICE-R version 2, formative feedback	pre-post survey	H	IPR and HPS	Patient with an acute medical crisis requiring immediate stabilisation. A nurse, a medical and a pharmacy students worked together to stabilise the patient. Debriefing was conducted immediately after the simulation (formative feedback).

Reference	Title	Population	Settings	Assessment	Study design	Simulation modality	Type of simulator	Scenario design/activity description
Brock, 2013	Interprofessional education in team communication: Working together to improve patient safety	4-year MS, 3-year NS, 2-year PS and 2-year PAS (n=306)	4h training included a 1-h TeamSTEPPS didactic session and three 1-h team simulation and feedback sessions.	TeamSTEPPS Teamwork Attitudes Questionnaire (TAQ); Attitude, Motivation, Utility and Self-Efficacy (AMUSE)	pre-post survey	H	IPR, LFM, SP	Students worked in groups balanced by a professional programmed in a self-selected focal area (adult acute, pediatric, obstetrics).
Candelario, 2019	Description of a transitions of care and telemedicine simulation lab activity	2-year PharmD PS (n=59)	1-hour TOC lecture, 1-hour introduction to review patient case, 15-min discharge simulation at the hospital bedside (with a manikin), 15-min follow-up telemedicine encounter (with SP). Six medication-related-problems (MRP) were incorporated into the activity.	student competency (activity document, telemedicine follow-up checklist and patient perception scale)	post activity assessment	SiP	SP	In telemedicine follow-up encounter, 2 SP portrayed the patient at a 72-hour follow up visit. Pharmacists utilised effective interview technique/assessment skills to identify MRP (including laboratory test indicated, cost, failure to receive therapy, completion of therapy, adverse drug reaction, indication without medication). Activity required students to collect, assess, create, and implement a plan and follow up.
Chen, 2015	Impact of an aging simulation game on pharmacy students' empathy for older adults.	1-year PS (n=156)	Students participated in an aging simulation game. The game incorporated the experiences and challenges of older adults in health care.	empathy (KCES, JSE-HPS), perceptions of older adults' experiences and game experiences (ASES)	pre-post survey	SiP	RP	Role-reversal activity where students "*role-played*" the older adult in 6 stations (physician's office, nurse practitioner visit, pharmacy, test and benefits, home, activities). Station facilitators mimic real health care providers and exhibit different amounts of empathy or caring. Reflective discussion at the end of the activity with facilitators.
Chen, 2011	Impact of the geriatric medication game on pharmacy students' attitudes toward older adults.	1-year PharmD students (n=624)	Students participated in the *Geriatric Medication Game*. Students "*became*" older adults during a 3-hour pharmacy practice laboratory.	reflection questions about experience and attitudes toward older adults (content analysis)	post activity assessment	SiP	RP	Students were given aging-related challenges (physical disabilities) and participated as patients in simulated healthcare scenarios. They navigated in health care system (physician's office, pharmacy, other healthcare provider, laboratory tests, home). Cards required students to incorporate diseases/medications in their RP.
Chen, 2008	Impact of patient empathy modeling on pharmacy students caring for the underserved.	PS (n=26)	Pharmacy students participated in 1 of 4 Patient Empathy Modeling (PEM) scenarios to complete over 10-days. They wrote a daily journal and a reflection paper.	empathy (JSPE) HP version	pre-post survey	SiP	RP	Each student "*became the patient*", simulating the life of an actual patient with multiple chronic disease who was coping with an economic, cultural or communication barrier to optimal healthcare. Debriefing session with

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								verbal feedback from preceptor and colleagues.
Chen, 2015	Evaluation of student perceptions of standardized patient simulation on patient counseling confidence during introductory pharmacy practice experiences	1-year PharmD PS (n=128)	Evaluation of students' perceptions about the usefulness of simulation in IPPE performance.	perceptions about patient counselling confidence	pre-post survey	SiP	SP	5-10 minutes to analyse the scenario before simulation with the SP (by using the required communication techniques). After encounter (20 min), SPs gave the student feedback regarding the communication techniques based on the developed rubric.
Christopher, 2019	Anemia interprofessional team role-play case for students in outpatient primary care	1-year PAS (n=41), 2-year PS (n=48)	Briefing with explication of the role of different healthcare professions, objectives, and instructions. 5 min to review the case individually. Formative debriefing session in large group after activity.	RIPLS	pre-post survey	H	IPR and SP	(1) PS acted as the patient during the first half of encounter (SP script). PAS performed history and physical exams on the PS before a collaboration in their respective roles. (2) Students switched roles and pharmacy students became the health care provider and counselled the PAS (now in the patient role) on the diagnosis, treatment plan and education regarding diet therapy, pharmacotherapy, and follow-up.
Clauser, 2020	Standardized patient simulation using SBIRT (Screening, brief intervention, and referral for treatment) as a tool for Iinterprofessional learning.	NS, PS, MS, PAS, SWS, dietetics, and occupational therapy programmes students (n=1255)	activity over 2 academic years. 2-hour online informational component and a 2-hour in-person application session. Participation was required as a class assignment in each profession-specific programme.	RR, teamwork, identification of potential substance misuse (question from SPICE-R, CSAT)	post activity assessment (impact survey)	H	IPR and SP	IP triad with a least one student prescriber in one of the 3 simulations. Feedback rubric for the observer role. Every student acted each role (patient, provider, observer) over the course of three cases. Formative feedback and feedback from SP. Large group debrief focused on the IP experience.
Cobb, 2019	Evaluation of an individualized vs non-specific standardized patient activity in improving communication skills amongst pharmacy students.	2-year PS (n=19)	20 min SP activity into individualised or a non-specific SP group. Communication skills rubric to identify the student's AOI in communication skills. Sessions videotaped for assessment.	communication skills (4-component 64-point rubric) and confidence (11-questions Likert survey)	pre-post survey	SiP	SP	SP with a glaucoma and issues using eye drop. Individualised group had and SP intervention activity tailored to their identified communication AOI. Non-specific group had an SP intervention activity with acting skills untargeted to any specific area.

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Cooke, 2017	Tracing the prescription journey: a qualitative evaluation of an interprofessional simulation-based learning activity.	3-year PS (n=10) and 4-year MS (n=9)	SBE activity with IPE. Briefing and learning objectives before simulation. Small mixed-disciplinary groups with the simulated patient.	IPE (focus group and thematic analysis)	qualitative evaluation	H	IPR and SP	(1) The medical student leads the consultation; the pharmacy student observes the interaction; (2) Medical and pharmacy students collaborate in the management plan; (3) a simulated pharmacist dispenses drugs to the SP
Cowart, 2021	Pharmacy student perception of a remote hypertension and drug information simulation-based learning experience in response to the SARS-CoV-2 pandemic	1-year professional PS (n=87)	Live didactic lecture and a laboratory instruction on performing manual blood pressure assessment. The hypertension/drug information SBL activity occurred after a patient vignette to prepare. Activity utilised Blackboard Collaborate Ultra, a web-based real-time video conferencing tool.	confidence in performing manual blood pressure technique, communication skills, drug information (formative feedback and Qualtrics pre-post survey)	pre-post survey	SiP	SP	In the virtual "*encounter room*", (1) the student was provided a drug information question from the medical provider; (2) the student verbalised step-by-step how to conduct a manual blood pressure assessment; (3) the student asked the patient for 3 minutes; (4) the student presented to the provider their response to the drug information request utilising SBAR.
Crowl, 2021	Determining the impact of an interprofessional simulation focused on social determinants of health among pharmacy students.	PS (n=121) and SWS (n=12)	60 min simulation: 8 min introductory/case review, 20 min pharmacy visit, 5 min consultation and transfer between pharmacy student and SW student, 12 min SW visit and 15 min group debriefing	confidence regarding substance use and impact of IP simulation (pre-post survey)	pre-post survey	H	IPR and SP	Pharmacy students discovers obstacles in the patient's management of diabetes (difficulty obtaining medication and respecting their diet, high-risk alcohol consumption, benzodiazepines). Pharmacy students consulted with their SW team member and included them in the visit to help address the issue of DSS and substance use.
Curley, 2019	Pharmacy students' perspectives on interprofessional learning in a simulated patient care ward environment	Bachelor of PS (n=97), 5-year MS and final year NS; (n=388)	2 days simulation-based course in an acute care, hospital ward setting (WardSim). Pharmacy students participated in day 2. 30-min scenario and 30-min debriefed for each case during 30 min.	IPL experience (Likert-type scale, open-ended items)	post activity assessment	H	IPR and SCI	4 IP scenarios: respiratory difficulty post-surgery, iatrogenic anticoagulant overdose, neurological symptoms and lithium, epileptic patient. Nursing and pharmacy students entered each scenario 15 min before medical students.
Curran, 2005	Influence of an interprofessional HIV/AIDS education program on role perception, attitudes, and teamwork skills of undergraduate health sciences students.	3-year NS (n=45), 2-year MS (n=62), final year PS (n=26), (n=133)	Problem based learning (PBL) format involving small groups (8-10 students from each profession). 3 occasions for 1 hour over a 3-week period. Session 3 with a SP.	IPE (Role Perception Checklist, Weekly Team Inventory, Participant Evaluation Survey, Team dynamics Observations Checklist)	pre-post survey	H	IPR and SP	Session 3 provided an opportunity for students to interact with a SP, who simulated a HIV/AIDS patient. The students were oriented with a brief history the SP prior to meeting him and were expected to collaborate as an interprofessional care plan.

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Davies, 2015	Changes in student performance and confidence with a standardized patient and standardized colleague interprofessional activity.	3-professional year PS (n=109)	Clinical-cases activity included a SP interaction, a SOAP note preparation, and a standardised colleague interaction. SP were actors trained at the university; standardised colleagues were volunteer family medicine physicians.	MTM (assessment rubric to evaluate interview skills, pre-post survey to assess comfort in counselling patient), IPE (pre-post survey to assess confidence in making recommendations to physicians)	pre-post survey	H	IPR and SP	Patient medication profile received before their interview with the SP. Students wrote a SOAP note to document their recommendations. They communicated evidence-based recommendations and issues to standardised colleague physician and defend their assessment plan.
Draime, 2020	Assessing the effects of a paired TBL session and patient simulation on pharmacy student HIV treatment knowledge.	2-year professional PS (n=48)	Baseline knowledge assessment before a 4-hour HIV TBL session, which included the use of an online HIV Patient Management Simulator. Post-simulation, students were again administered the scale.	MTM knowledge assessment (HIV Treatment Knowledge Scale)	pre-post survey	SiP	SP	HIV patient simulation: new antiretroviral plan to a patient diagnosed with HIV 2 years prior that had not received treatment. The patient had oropharyngeal and esophageal candidiasis, as well as a decreased CD4 count and increased HIV viral load.
Efstathiou, 2013	Interprofessional, simulation-based training in end-of-life care communication: a pilot study.	final year students (n=50) in MS (n=14), NS (n=18), PS (n=7), physiotherapy (n=11)	3 end of life scenarios, video recording enabled observation and retrospective viewing, RP with a professional role player, facilitated feedback and group discussion.	IPE knowledge, skills, confidence, competence in end-of-life care communication (Likert scale rating questionnaire based on RIPLS and IEPS)	pre-post survey	H	IPR and RP	Scenario before death, during the last days of life and after death. Feedback based on video replay, fear in the box (acknowledgment of fears and anxiety in each situation) and management of interaction in a different context.
Egelund, 2020	Recognizing opioid addiction and overdose: An interprofessional simulation for medical, nursing and pharmacy students	3-year PS (n=19), 3-year MS (n=16), NS (n=32), (n=67)	High-fidelity overdose in IP team using SBIRT IP communication to analyse recorded scenarios. 5 min briefing, 15 min simulation, 10 min debriefing immediately after the simulation at the bedside.	Frankel's Communication and Teamwork Skills (CATS) assessment tool	post activity assessment	H	IPR, HPS, SP	Motor vehicle accident while under the influence of opioids. The IP team was exposed to an opioid overdose and SBIRT tool were used.
El-Den, 2018	Assessing mental health first aid skills using simulated patients.	4-year bachelor PS (n=163)	Tutors enacted vignettes. 30 minutes interaction were audio-recorded. Experienced tutor in MHFA assessment (on reflected performance) and self-assessment (confidence) post-training.	MHFA skills (ALGEE assessment rubric), self-perceived confidence	post activity assessment	SiP	RP	Postnatal depression and suicide vignette were required each student perform in different skills in an over-the-counter request, a first-aid situation, a discharge, a drug information, a medication-related ethical dilemma, a patient's medication history, a Home Medicines Review (HMR).

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Estes, 2016	Discovering eHealth technology: An innovative interprofessional graduate student learning experience.	advanced practice registered nurse student, 2-year Doctor of PS (n=15)	Implementation of a telehealth-learning experience, students were paired to form an IP team. Actor trained to portray SP. Students were provided a brief patient history including the initial indication and instructions for the use of the telehealth tools.	IPE qualitative evaluation (open-ended questionnaire to evaluate telehealth experience)	post activity assessment	H	IPR and SP	Simulated telehealth in a simulated IP clinical environment. IP team conducted a telehealth patient visit with a SP in videoconference, with telehealth monitoring tools and simulated academic electronic health record (EHR). SP case involved a patient with an history of heart failure, obstructive sleep apnea, and hypertension.
Eukel, 2021	Simulation design, findings, and call to action for managing difficult patient encounters.	3-professional year PS (n=236)	3 students cohorts participated in the simulation. Simulations scenarios represented difficult patient encounters. 50-minute didactic lecture and a 2-hour laboratory session each week.	ability to communicate during difficult patient encounter (self-assessment 0-100 scale)	cohort, pre-post survey	SiP	RP	3 roles: actor, student facilitator, student pharmacist. Actors in each scenario portrayed attributes that required students to respond using specific communication techniques, and to use soft skills from the affect domain. Scripted actors were angry, embarrassed, worried, in pain or hurried and were sometimes resistant to plan of care.
Fejzic, 2015	Implementing simulated learning modules to improve students' pharmacy practice skills and professionalism.	4-year PS (n=95)	Simulation learning modules (SLM), 3 hours of lectures and 8 hours of workshop. SLM focused on specific scenarios from practice and placements RP with trained actors.	professionalism (Measure of Pharmacy Professionalism scale), pharmacy practice skills (Measure of Pharmacy Practice skills scale), qualitative data about student's evaluation	mixed method, pre-post survey	SiP	RP	Each SLM included a briefing, role-playing with actors, animation, debriefing on social interaction cards (SIM). During the role play, the community pharmacist shows a disagreement with the hospital regarding a medicine. Pharmacist should comment on cross-sensitivity for allergy.
Fejzic, 2016	Communication capacity building through pharmacy practice simulation.	4-year PS (n=94)	SLM lectures and workshops over a 6-weeks period. 6 SLM themed around pharmacy practice and pharmacy placements comprised RP with actors, facilitation using Social Interaction Maps (SIMs) and debriefing. Evaluation of long-term effect on self-perceived practice skills.	quantitative (SLM evaluation) and qualitative surveys (open-ending question coding)	mixed method, pre-post survey	SiP	RP	RP focusing on interactions between pharmacy colleagues, pharmacists and other health professionals, pharmacists and patients, and preceptors and students. Actors participated in all SLM workshops, assisting with the demonstration of scenarios in one-on-one RP, as well as post practice debriefing.

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Flores, 2018	Comparing teaching methods on skin disorders using standardized patients dressed in moulage vs paper cases.	3-professional year PS (n=70)	50-min lecture on drug induced skin disorders (DI) and contact dermatitis (CD). 90 minutes laboratory. Teams of 5 on 4 skin disorders (2 SP cases and 2 paper cases), 20 min per case in a cross-over design. Survey before and immediately after laboratory, final examination 3 weeks later.	knowledge, confidence in skin disorder assessment, satisfaction (multiple-choice questions)	observational (cross-sectional) pre-post survey	SiP	SP	(1) groups completed a picture-based paper case, or an interview of a SP dressed in CD-like with a moulage. (2) groups completed 2 cases on DI skin disorders and reviewed (a picture-based paper case or a SP dressed in DI-like moulage) in a cross-over design. Students were asked to identify the skin disorder, determine the cause, and make a recommendation to the patient (triage decision).
Frenzel, 2019	Measuring health care students' attitudes toward interprofessional learning, perceptions of effectiveness as an interprofessional team member, and competence in managing adult cardiac arrest.	3-year PS (n=93) and senior NS (n=57)	60 min of simulation (included 10 min pre-briefing and debriefing)	RIPLS, TSS surveys	pre-post survey	H	IPR and HPS	HFS using HPS focused on adult cardiac arrest in IPR. Discharge education by 2 students of either discipline. Other students observed the interaction in a conference room.
Fusco, 2020	Impact of pharmacy student observation versus active participation in an interprofessional simulation	2-year PS (P2, n=130), 3-year PS (P3, n=121), senior NS	Active participants were P3 and NS (teams of 4), P2 were observers. Scenario synopsis before the simulation, 2 IP simulation cases, debriefing.	ICCAS	pre-post survey	H	IPR and SP	Scenario 1: TOC, with an older adult patient after acute coronary syndrome episode. Scenario 2: medication error and hypoglycemia due to incorrect dose of insulin
Fusco, 2021	Interprofessional escape room improves knowledge and collaboration among nursing, pharmacy, and physical therapy students.	senior NS, 3-year PS and 2-year physical therapy programmes students (intervention group, n=133, control group, n=129), (n=262)	Activity included 1-hour asynchronous online learning about sepsis management and post-operative hip precautions prior escape room: (1) acute management of sepsis (intervention group), (2) general acute care (control group) escape rooms. Students were divided into teams of 2 pharmacy, 2 nursing and one physical therapy student. 30 minutes to complete the escape room prior to participating in a simulated patient discharge case.	Knowledge assessment and impact study. Interprofessional Socialisation and Valuing Scale (ISVS-21)	pre-post survey	H	IPR and SP	Escape room included puzzles focused on the theme of sepsis management and post-operative precautions for patients following total hip arthroplasty. The control escape room included puzzles focused only on general knowledge of acute care practice. After participating the escape rooms, students were tasked to create a discharge plan to a SP with hip arthroplasty complicated by sepsis. Plus-Delta debriefing framework.

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Galal, 2012	Development and assessment of social and emotional competence through simulated patient consultations.	1-year PS (n=212)	Students completed the Social Emotional Development Inventory (SED-I) online and then participated in a series of mock patient consultations on smoking cessation and non-prescription medication.	self-perceived social emotional competence (quantitative tool, 48-items self-report measure) and social competence in patient counselling (patient counselling assessment form)	post activity assessment	SiP	RP	Students conducted simulated patient consultations (smoking-cessation, non-prescription medication counselling exercises) in which they provided recommendations for self-care, assessed the patient and provided a treatment plan.
Gallimore, 2008	Pharmacy students' preferences for various types of simulated patients.	2-year PS (n=155)	Students were observed in live or using a streaming video by an instructor using an evaluation rubric. A survey tool evaluated student's preferences and experiences working with the different types of simulated patients.	self-perceived skill development (communication, medication education) and preference (survey tool)	post activity assessment	SiP	SP	Students were exposed to a simulated patient through a progression of health problems, from dyslipidemia and hypertension to coronary artery disease, to atrial fibrillation with warfarin anticoagulation. Simulated provided formative feedback to student using a separate evaluation tool.
Gillette, 2017	Improving pharmacy student communication outcomes using standardized patients.	2-year PS (n=220)	quasi experimental design to compare effectiveness of 2 active learning methods in the flipped classroom model: case studies, discussion, peer-RP vs 5 SP encounters	communication skills (high-stakes communication assessment, counselling assessment rubric)	post activity assessment	SiP	SP	Prior speaking with the SP encounter, students researched the case and corresponding medications. Patient cases focuses upon the topic of the day (risk communication, health literacy). Students counselled the patients following the same rubrics that would later be used to assess the student during the communication assessment.
Gough, 2013	Innovations in interprofessional learning and teaching: Providing opportunities to embed patient safety within the pre-registration physiotherapy curriculum. A Pilot Study	undergraduate physiotherapy, nursing, MS and PS (n=13)	4 consecutive days course. Topics were taught sequentially with tutorials, group activities, video cases studies, simulated case scenarios. Evaluation of perceptions post-course and perceived application of knowledge 3-month later.	perception IPE, perception patient safety (RIPLS, thematic analysis)	sequential mixed method	H	IPR and SP	2-hours ward scenario, during which participants were required to manage 4 SP, a high-fidelity simulated patient and admit a new SP from the medical assessment unit. Each SP completed a simulation observation sheet which was used to provide feedback during the debrief. 1,5-hour faculty lead debriefing.
Grice, 2013	Health literacy: Use of the Four Habits Model to improve student pharmacists' communication.	3-year professional PS (n=191)	Utilisation of the Four Habits Model (FHM): (1) introduction to FHM in a patient interview lecture, (2) practice interview with SP, formative assessment, (3) practice interview in lab, formative assessment, (4) final	relational aspects of student pharmacist-patient communication skills (FHM criteria formative and summative assessment with SP)	post activity assessment	SiP	SP	Students practiced FHM during an SP simulation: (1) establish rapport and build trust rapidly, (2) facilitate the effective exchange of information, (3) demonstrate and concern, (4) increase the likelihood of adherence and positive health outcomes.

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			interview with SP, summative assessment					
Guadalupe, 2014	Patient simulation-based learning in pharmaceutical care subject provided to fourth-year pharmacy students in Spain	4-year PS (n=70)	Communication modules and practice laboratories to facilitate the implementation of communication skills. Students were assigned to groups of 7 and play the role of pharmacists in a community pharmacy setting in which 10 simulated patients experienced 10 case scenarios.	satisfaction (anonymous questionnaire), communication skills and knowledge application (grading rubric, formative feedback)	post activity assessment	SiP	RP	Consultation with a simulated patient (cold, constipation, cough, diarrhea, hemorrhoids, headache, heartburn, eczema, osteoporosis). Student was asked to meet the patients' pharmacotherapeutic need and resolve drug related problems. The consultation was filmed and recorded. Students viewed the video and evaluated the process to determine the strengths and weaknesses.
Gulpinar, 2021	Development of a structured communication and counseling skills course for pharmacy students: A simulation-based approach.	undergraduate PS (n=21)	A Pharmacist-Patient Communication and Counselling Skills education (PPCCE) programme with simulated patient as teaching method. Videotapes for assessment.	communication skills (modified version of the patient-centered communication tool PaCT)	mixed method	SiP	RP	4 scenarios: (1) a patient with type-2 diabetes afraid of giving injections to himself; (2) a patient with osteoporosis afraid about the side effects of the drugs; (3) an insistent patient wanting the pharmacist to persuade her daughter to use a food supplement; (4) patient with osteoporosis with a medication issue
Haddad, 2010	What health science students learn from playing a standardized patient in an ethics course.	PharmD PS (n=7) and health NS in senior year	4 clinical simulations with SP that focused on different ethical issues and designed to be a teaching/learning tool. All students provided written consent to participate in the project. SP were trained 90 min prior the simulation.	emotions on communication in crisis situations (self-reflection, open-ended question)	qualitative evaluation and thematic analysis	SiP	SP	The clinical simulation (10 min) involved a young childbearing-age woman who is taking a highly teratogenic drug, isotretinoin, and suspects that she might be unintentionally pregnant. Time at the end for feedback from the SP and basic communication skills.
Hamilton, 2021	Evaluation of inter-professional education (IPE) with medical, nursing and pharmacy students through a simulated IPL	final year MS and NS and pre-registration pharmacy trainees (n=118)	One day simulated IPE intervention "*Evening On-Call*" involving nursing, medical and pharmacy students in an on-call setting. Manikin and actor patients in a simulated ward. Post-IPL questionnaire	IPE perceptions (pre-post questionnaires)	pre-post survey	H	IPR and SP	Each participant was provided a document, which detailed the patient on the wards to mimic practice. The participants were blinded to the scenarios prior of the start of the session. After each 60-min session, participants reflect on their experience

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	educational intervention.		immediately after completing intervention and follow-up 6 months after intervention.					and discuss the session with a trained facilitator from their own profession.
Hannings, 2016	Assessment of emergency preparedness modules in introductory pharmacy practice experiences.	2-year PS (n=144)	3 hours simulation focusing on mass triage and mass dispensing. The mass triage consisted of virtual and live victims to be triaged and assigned a transport order.	Mass triage exercise and mass dispensing skills (performance and perceived competence)	mixed method, post activity assessment	SiP	RP	SP triage following a mass casualty event. Evaluation of each victim and categorisation in the mass triage. In the mass dispensing simulation, students assumed patient and pharmacist roles in a point of dispensing exercise of influenza. Each student rotated through 3 roles: simulated patient, pharmacist, and case reviewer.
Harris, 2018	The use of a disease state simulation assignment increased students' empathy and comfort with diabetes nutrition counseling.	PS (n=140)	Students in the intervention group completed an empathy assignment, which involved developing and following a diet plan appropriate for a patient with diabetes followed by a reflection of their experiences.	empathy (Kiersma Chen Empathy Scale)	pre-post cross-over survey	SiP	RP	3 half-days rotation per week for 5 weeks. Patient encounters varying from 30-60 minutes, with patient from different cultural and socioeconomics background. The intervention group as to live as a patient with diabetes for one week.
Hollamby, 2018	Preparing students for safe practice using an interprofessional ward simulation	5-year MS, 3-year NS, 3 and 4-year PS, (n=92)	Interprofessional ward simulation: 7 half-day simulation sessions. Each session comprised 3 simulations through which the students rotated.	confidence, role understanding, awareness of patient safety issues (pre-post questionnaires), Kirckpatrick Training Evaluation Model was applied	pre-post survey	H	IPR, LFM, SP	Students acted into their respective professional roles on ward or into patient /relative roles. 2 beds held high fidelity manikins, one a low fidelity manikin and 5 beds contained simulated patients, played by students. Debriefing sessions followed simulations.
Hussainy, 2012	A virtual practice environment to develop communication skills in pharmacy students.	2-year PS	Virtual practice environment (VPE): a video of a real-life community pharmacy in operation on a regular day was recorded and displayed over 3 screens as a "*backdrop*". VPE included cameras to recorded class role plays.	OSCE, evaluation of students' experiences and focus group	mixed method	SiP	RP	Students viewed prescriptions and practiced RP with each other and explored the use of non-verbal communication in patient-pharmacist interactions. Barriers that usually occur in the community pharmacy were maintained in the video (noise) to create an immersive environment. Each group was able to access electronic drug information databases to search information. Tutorial included

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								antibiotics, asthma medicines and antihypertensives.
Isaacs, 2015	A chronic disease state simulation in an ambulatory care elective course.	PS (n=130)	2 weeks of simulation. Students alternating playing the role of patient and pharmacist after one week.	empathy, counselling skills (course surveys, written reflections, SOAP notes)	post activity assess ment	SiP	RP	Chronic disease state simulation activity (hypertension, diabetes, dyslipidemia, rheumatologic disorders, respiratory diseases, depressive and anxiety disorders), done in pairs, with students alternating the roles of pharmacist and patient.
Iverson, 2018	Development and assessment of an interprofessional education simulation to promote collaborative learning and practice.	Doctor of NS (DNP, n=16), PharmD Doctor of Pharmacy (n=23), (n=39)	25 minutes to complete the scenario in both the outpatient and inpatient setting and an additional 5 minutes for the transfer of care telephone call between providers. 5 minutes allowed for immediate feedback to acute care students. Each simulation involved 2 NS and 1 pharmacy student.	perceptions, attitude toward IPE (SPICE-R, reflection questions)	mixed metho d	H	IPR and SP	Simulated patient presented to the primary care requiring transfer to an acute care facility. The primary care DNP student evaluated the patient's condition, collaborated with the outpatient PharmD student, and made recommendation. The primary care student provided report in SBAR format for the acute care student.
James, 2001	The design and evaluation of a simulated-patient teaching programme to develop the consultation skills of undergraduate pharmacy students.	3-year undergraduat e PS (n=91)	Questionnaires were administered before and after delivery to the teaching programme. 6 scenarios involved pharmaceutical interventions to address patient's illness and treatment.	perceptions of the difficulty of conducting a consultation, confidence (structured questionnaire)	pre-post survey	SiP	RP	2 scenarios were constructed around the need to take a thorough medication history. 2 scenarios focused on patient compliance. 1 scenario involved a sensitive chronic medical condition. Students were divided into 3 groups of 4, and each group was given a scenario. One student of the group was nominated to undertake the consultation with a (volunteer) simulated patient.
Jebara, 2021	Pharmacy and medical student interprofessional education placement week.	3- and 4-year PS and MS (n=10)	5-day IPE for pharmacy and medical students (ward rounds, outpatient clinics, investigations, and interventions). Students completed mini-Clinical Evaluation exercises in their pairing (medical and pharmacy student).	IPE qualitative evaluation (focus group), Kirckpatrick Training Evaluation Model focused on levels 1 and 2	post activity assess ment	H	IPR and SP	Ward-based immersive simulation: students 'acted-up' as qualified junior pharmacists and doctors. Simulated patients in a ward setting. At the end of the scenario, students were debriefed on their experience by the placement coordinator.

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Joyal, 2015	Interprofessional education using simulation of an overnight inpatient ward shift.	1-year MS, 2-year NS, 3-, 4-year nursing, 2-year MS, 4-year PS, (n=45)	Academic staff from 3 faculties served as mentors. The shift included IP ward rounds, simulated patient records and staged patient event. Debriefing session with faculty in the morning prior to student's departure.	perceptions about IPE (4-questions using a 10-point Likert scale, open-ended questions)	pre-post survey	H	IPR and SP	IPE, overnight inpatient ward shift: 1-year medical, 2-year nursing performed the role of SP in a simulated 12-hour night simulation called Nightmare Night Care (NMNC). 3-, 4-year nursing, 2-year medicine, 4-year pharmacy students performed their respective roles.
Jung, 2020	The effectiveness of interprofessional education programs for medical, nursing, and pharmacy students	final year MS (n=42), final year NS (n=46), final year PS (n=29), (n= 116)	6-hour period on a single day IPE activity (small-group activities and roleplay). Intervention group and control group.	Perceptions toward Interprofessional Education (PIPE), Self-Efficacy for Interprofessional Experiential Learning (SEIEL), Perceptions towards Interprofessional Competency (PIC), satisfaction	pre-post survey	H	IPR and patient chart/case	Scenario simulated a medication error due to the absence of IP communication. Students were led to detect problems and solutions through roleplay.
Karpa, 2019	Geriatric assessment in a primary care environment: A standardized patient case activity for interprofessional students.	MS (n=142), NS (n=55), occupational therapy (n=48), physical therapy (n=36), PS (n=30), dental hygiene (n=21), dietician (n= 8) students (n=340)	Intercollegiate collaboration involving 7 colleges. 30 minutes for students' instructions. 14 simultaneous simulation rooms (with a physician facilitator) during the 1st day and 16 the 2nd day.	Interprofessional Self-Assessment Questionnaire	pre-post survey	H	IPR and SP	Each student participates in one encounter, each SP portrayed a geriatric patient for one day. Each experience occurred over 180 minutes, 2 hours interaction with the SP and 30 minutes debriefing.
Kayyali, 2016	Simulation in pharmacy education to enhance interprofessional education.	PS (n=126), NS (n=314)	Simulated hospital ward and a general practitioner (GP) for a simulation setting model (SSM) specific for SBL in healthcare. 4 phases: (1) introduction, (2) briefing, (3) scenarios, (4) debriefing.	IPE (20-item questionnaire, short interview for a thematic analysis)	post activity assessment and thematic analysis	H	IPR and RP	In the hospital setting, the environment resembled a hospital ward and trained amateur role-players played patients dressed in hospital gowns and wearing makeup to reflect injuries, intravenous (IV) lines. At the bedside, facilitators act as a nurse in charge and prescribers where necessary. Phone calls could be made and received during this time.

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Kerr, 2021	A realist evaluation exploring simulated patient role-play in pharmacist undergraduate communication training.	3-year PS (n=183)	SP session in a men's and women's health module. The class was split into randomly assigned small groups of 12 students for the training session, with students divided into six pairs. Sessions took place in a simulation center.	complex communication skills (Explanation and Planning Scale EPSCALE, video recording of training and OSCE sessions, focus group)	mixed metho d	SiP	SP	Students rotated through 6 scenarios in pairs (smoking cessation, alcohol in pregnancy, emergency hormonal contraception, erectile dysfunction, medication teratogenicity), with students taking it in turns to act as pharmacist and observer. 5 minutes for each interaction. During the debrief session, all student in the small group watched one video of each student's interaction.
Kerr, 2015	Assessing empathy and self-efficacy levels of pharmacy students in an elective diabetes management course.	3-year PS (n=24 in 2012; n=30 in 2013)	Pharmacy students enrolled in a diabetes elective course were paired to act as a patient with diabetes or as a provider assisting in the management of that patient during a 6-week simulation activity. After 3 weeks, students switched roles.	empathy (Jefferson Scale of Empathy JSE-Health Professional) and a self-efficacy (survey)	pre-post survey	SiP	RP	The simulation was designed with activities to build empathy. The patient/provider interaction simulation activity randomly paired students, with one assigned the role of patient and the other, clinical pharmacist provider. The patient consulted a physician. A course coordinator acted as the "*community pharmacist*".
Kiersma, 2009	Laboratory session to improve first-year pharmacy students' knowledge and confidence concerning the prevention of medication errors.	1-year PS (n=160)	Skill based laboratory divided into 5 sections of 32 students and designed to allow students to apply material from lectures and share experiences from personal observations in pharmacy setting. Students received instructions on strategies for medication error reduction in course.	3 survey instruments: (1) knowledge regarding medication error prevention, (2) confidence in preventing and resolving errors, (3) laboratory evaluation. Measure of the correlation between knowledge and confidence scores.	pre-post survey	SiP	SP	The simulated prescription contained a variety of misinformation, making errors likely to occur during prescription intake. One facilitator per small group acted as the patient/caregiver. The second laboratory activity was a RP scenario on how to manage and communicate errors once they occurred.
Komperda, 2019	Effectiveness of a medication reconciliation simulation in an introductory pharmacy practice experience course.	3-year PS (n=183)	3 groups of pharmacy students (A, B, C). "*A*" attended a 30 min lecture, "*B*" attended the lecture and participated in a 90 min workshop, "*C*" received no training. After A et B completed their assigned learning activities, all students participated in a simulated medication reconciliation activity with a SP.	pre-post intervention survey, formative assessment of the SP encounter (feedback on performance and recommendations)	pre-post survey	SiP	SP	Medication reconciliation simulation: 10 min to review the patient's electronic medical record, 15 minutes to interview the patient and review medication, 30 minutes to complete a post-encounter task documenting the patient's reconciled medication list.

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Koo, 2014	Qualitative evaluation of a standardized patient clinical simulation for nurse practitioner and pharmacy students.	PS (n=14) and nurse practitioner (n=32)	8-hour day course, students were divided into 3 group and rotated through the 2 clinical scenarios.	IPE (qualitative data from 3 focus groups, content analysis)	qualitative evaluation	H	IPR and SP	Vaccination case scenario in a community pharmacy which required students to communicate by telephone and videoconferencing. Anticoagulation therapy clinical scenarios included history taking, physical examination, communication with another healthcare. Tasks were divided among nurse practitioner and pharmacy students, and they turn actively participating in the scenario while the other students observed the simulation.
Kostoff, 2016	An interprofessional simulation using the SBAR communication tool.	senior NS (n=94), 3-year PS (n=96)	60-minutes simulation, 30-minutes debriefing. During each simulation, the pharmacy and nursing groups had to communicate and collaborate on 4 separate cases, with each case lasting 15 minutes.	ICCAS	mixed method	H	IPR and patient chart/case	Students used telephones and the SBAR communication tool to collaborate on the development of a shared plan. The simulation created communication from pharmacy settings to the corresponding nurse settings regarding a variety of clinical content (drug interaction, narcotic use, immunisations, patient education, drug administration/monitoring, inpatient order clarification, adverse drug reaction). For 3 cases, a pharmacy student was the SBAR communicator, for the fourth case, the roles were reversed.
Kubota, 2018	Clinical pharmacy education in Japan: Using simulated patients in laboratory-based communication-skills training before clinical practice.	4-year PS (n=242)	3 days laboratory work. 4 groups for each session with 1 faculty member 1 simulated patient per group/case. Feedback by both the simulated patient and the faculty after each presentation.	knowledge, skills, and attitude (questionnaire survey)	post activity assessment	SiP	RP	Students were asked to obtain patient data from a model medical chart, before performing simulated patient interviews covering hospital admission and patient counselling. Next day, 1 representative group simulated the patient interview in front of the whole class.
Kusnoor, 2019	An interprofessional standardized patient case for improving collaboration, shared accountability, and respect in team-based family discussions.	4-year PS (n=464), 3 and 4-year MS (n= 450), 4-year NS (n=237)	70 minutes sessions. Teams to disclose a medical error to a SP. Icebreaker exercise wherein students learned about each other's. Students worked in teams of 3 (nursing, medical and pharmacist).	IPE team performance, IPC, communication (post-session survey)	post survey	H	IPR and SP	Teams disclosed a medical error. An 80-year-old patient was erroneously given an overdose of heparin. The son returned to the hospital at the request of the team to discuss what happened to the patient. After simulation,

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								students regrouped for a 30-45-min debriefing.
Lucas, 2020	"*Two heads are better than one*"- pharmacy and NS' perspectives on interprofessional collaboration utilizing the RIPE model of learning.	1-year master PS MPharm (n = 56), NS (n = 8)	RIPE model applied in a simulation laboratory (multiple workstations between pharmacy and NS). Students were allowed a maximum of 15 minutes per station.	pre and post survey (6-point Likert-type scale) and debriefing session with written reflective statement	mixed method	H	IPR and RP	Pharmacy students gathered information in 10 workstations (including a patient or a healthcare professional). 4 workstations were hospital bedside stations, which included either a medium or high-fidelity manikin or a SP. The final station involved a SP in bed.
Luiz, 2015	Developing pharmacy student communication skills through role-playing and active learning.	2-year PS (n=92)	Pharmacy students divided to take the class over 2 terms. Practice role-playing sessions were scored as a baseline measure to compare to later sessions.	oral communication skills (evaluation rubric inspired by Bruce Berger's Communication Skills for Pharmacist), written communication skills (written critique questionnaire)	pre-post survey	SiP	RP	All students search for patient drug information, received patient scenarios, and read assigned chapters from Berger's book (communication skills for pharmacists). Oral communication in the scenarios emphasised course goals as well as development of cultural competency, patient conflict and anger management, techniques for assertiveness and persuasion, and appropriate diction and nonverbal signals.
Lynch, 2018	Assessment of a simulated contraceptive prescribing activity for pharmacy students.	3-year PS (n=11)	PS learned about relevant state legislation and attended a clinical skills center simulation activity where they utilised a prescribing algorithm. Students attended workshop in 2 groups. Each student was randomly assigned 2 of the 3 scenarios.	clinical decision-making, interpersonal skills (faculty graded clinical decision making based on assessment and plan)	observational (cross-sectional) survey	SiP	SP	SP scenarios were designed to mimic realistic situations: a contraceptive start, adjusting an oral contraceptive dose and referral to the physician in the presence of exclusion criteria for contraceptive prescribing. Students had 20 min to meet with the SP individually, make a recommendation, counsel the SP, and electronically document the assessment.
Ma, 2020	Evaluation of distance facilitation and technology in an interprofessional simulation exercise.	3-year MS (M3), 3-year NS (N3), SWS, medical doctor (MD), registered nurse (RN), 3-	Hawaii Interprofessional Team Collaboration Simulation (HIPTCS) and involved an IP team's hospital discharge for a complex geriatric patient. The HIPTCS sessions consisted of four on-site rooms conducted	ability to work through the simulation, satisfaction with the use of distance technology (questions to facilitators and students)	mixed method	H	IPR and SP	IRP with distance technology: (1) collaboration case (complex geriatric patient) and required on-site and distance students; (2) students from each profession represented their respective discipline when the team met a family member to develop a

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		year PS (P3) n=875 over 3 years	simultaneously with 8-10 students (M3, N3, PH and/or SW students). Each room included a team of interdisciplinary co-facilitators.					patient-centered, culturally appropriate plan of care. A theater arts student plays the role of the family member.
MacDonnell, 2012	An introductory interprofessional exercise for healthcare students.	2-year MS, 4-year NS, 3-year PS (n=251)	Teams alternated between working together on patient cases focusing on chronic obstructive pulmonary disease and asthma, and on the evaluation of standardised pneumonia patient (SP).	teamwork (global rating scale for faculty member and SP), perceptions (voluntary questionnaire prior and after workshop)	post activity assessment	H	IPR and SP	IP workshop that introduces students to a team-based, patient-centered care experience. Teams were given the patient's health information and went to examination rooms to assess, diagnosis and develop treatment plans for a SP with pneumonia.
MacDonnell, 2016	A team-based practicum bringing together students across educational institutions and health professions.	4-year NS (n=120), 2-year MS (n=121), 3-PharmD PS (n=120), 2-year SWS (n=48), 2-year Doctor of Physical Therapy Students (n=34)	Students collaborated in assigned health professions teams. The workshop included 3 activities through which the groups rotated. The focus was on the activity with the SP case.	SPICE-R	post activity assessment	H	IPR and SP	The SP (a patient actor) presented to the emergency department with a laceration. He received the wound into a financial argument with their partner. Teams were asked to take a patient history, perform a focused and brief physical examination, make a diagnosis and perform a procedural component.
Marken, 2010	Human simulators and standardized patients to teach difficult conversations to interprofessional health care teams.	senior PS (n=1), 1-year pharmacy resident (n=3), pediatric medical residents (n=3), senior NS (n=4), pediatric emergency medicine fellow (n=1)	Teams responded to preliminary questions regarding difficult conversations, listened a brief discussion on difficult conversations, formed teams to interact with the SP and debriefed and self-reflection.	interprofessional teams in difficult conversation self-assessment	observational (cross-sectional) per-post survey	H	HPS, SP and IPR	Pharmacy students and residents, students' nurses and medical resident formed ad hoc teams and interacted with a SP (mother) and a human simulator (child), discussing the infant's health issues, intimate partner violence and suicidal thinking.

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Marshall, 2020	A mixed methods approach to assess the impact of an interprofessional education medical error simulation	4-year MS (n=85), 3-year PS (n=50), 2-year PAS (n=15), NS (n=36), (n = 186)	Half-day high-fidelity IPE error disclosure simulation. Online assignments on medical error disclosure prior simulation (readings, videos). IP teams of 4 or 6 members. Focus group 8 month after the simulation.	IP attitude (IPAS survey and focus group)	mixed method	H	IPR and RP	Health care team interact with the patient's parent (actor) and inform on a medical error: child was inadvertently given potentially toxic doses of an ototoxic antibiotic. 3 interactions with a different actor's demeanor (disbelief, anger, sadness) during the simulation.
Mathews, 2011	Role-reversal exercise with Deaf Strong Hospital to teach communication competency and cultural awareness.	1st-year PS (n=76)	Students were the patients in a Deaf Hospital. Volunteers from a local deaf community acted health provider.	cultural competency, debriefing session, role-reversal exercise	post activity assessment	SiP	RP and SHP	Standardised health care providers. Students navigated into a hospital and received a prescription filled at a pharmacy without receiving or using any spoken language.
Miller, 2020	Ambulatory care elective: Introduction to core practice concepts.	3-year PS (in a 4-year Doctor of Pharmacy programme) n=43	The ambulatory elective course included six modules employed lecture, active learning activities, role playing and simulation. An online web conferencing system allowed the practicing pharmacists to provide real time feedback to students.	satisfaction and students' reflections	post activity assessment	SiP	RP	Role-reversal multiple chronic disease state simulation (diabetes and hypertension/ hypothyroidism/chronic obstructive pulmonary disease). Students experienced the role of a patient (with a medication and monitoring of glucose, diet, and exercise) and the role of a pharmacist (to provide a standardised interview sheet and create an individualised medication).
Moote, 2019	Interprofessional education telephone simulation for campus-based pharmacy students and distance-learning family nurse practitioner students.	4-year PharmD PS (n=36) and Family Nurse Practitioner (FNP) students (n=10)	1 FNP and 2 pharmacy students in each team. 1 week to complete the activity via telephone conversation.	perception of team communication (post-simulation perceptions assessment survey), patient care plan, team concordance (rubric to assess therapy and concordance among groups)	post activity assessment	H	IPR and patient chart/case	IPR in telephone simulation. Interprofessional work by teams to achieve optimal patient care (to develop a treatment plan in an ambulatory anticoagulation case and a complicated urinary resistant infection case).
Motycka, 2018	Using interprofessional medication management simulations to impact student attitudes toward teamwork to prevent medication errors	2-3-year PS (n=15), half-way programme NS (n=21), 4-year MS (n=12), (n=48)	TeamSTEPPS simulation: teams of 4 students, introduction by a faculty facilitator, 15-min scenario, 10-min debriefing.	Teamwork Attitude Questionnaire (TTAQ)	pre-post survey	H	IPR and HFS	4 simulated IPE MTM scenarios: (1) febrile baby with the wrong chart; (2) allergy to penicillin; (3) rash, kidney-based drug toxicity; (4) spider bite and MRSA. Debriefing took place after each simulation.

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Nestel, 2007	Using volunteer simulated patients in development of pre-registration pharmacists: Learning from the experience	4-year bachelor PS, n=121	Students worked in groups of 8 with experienced pharmacist tutor and SP. Each student was the pharmacist in a 5-min RP and then receive feedback from the simulated patient, peers, and tutor. Each role was played twice in each group, with a different student and simulated patient.	evaluation forms for students, tutor, and SP	post activity assessment	SiP	RP	Scenarios of real-life interaction (hemorrhoids, stress headache, hay fever and advice on smoking cessation). Simulated patient interview and colleagues' observation in different scenarios. Facilitation by an experienced pharmacist. SP, students, and tutors participated in feedback.
Norville, 2021	The design, implementation, and evaluation of hybrid cancer clinic simulations: Escaping the norm.	3-year PS (n=36)	6 groups completing a series of Pharmacist Patient Care Process (PPCP) activities involving patient actors. PPCP activities were puzzles and games to simulate an escape room.	knowledge in cancer pharmacy patient care process (learning and retention measured by pre-post simulation quizzes and course exams), perception (post-simulation survey)	mixed method	SiP	SP	SP actors performed the role of the cancer patient, and a pharmacy faculty member played the role of the physician in 2 cancer clinic simulation: teams counselled the SP on conveying patient-specific recommendations in (1) a newly diagnosed non-small cell lung cancer patient, (2) a newly diagnosed lymphoma patient, in prevention of chemotherapy-induced nausea and vomiting.
Ottis, 2016	An interprofessional nursing and pharmacy student simulation in acute pain management	4-year PS and 3-year NS (n=343)	IPE exercise integrated into existing courses for both the nursing and pharmacy school.	IP attitude toward acute pain (pre-post survey validated tool adapted for the specific needs of simulation), ability to identify drug-related problems (analytical checklist)	pre-post survey	H	IPR, SP, manikin	Simulation of a post-operative patient recovering from a hip replacement. Pharmacy students were provided to review medications. SP received inappropriate dosing of morphine. Pharmacy and NS continued to discuss patient concerns and the identified potential threats to patient safety as an interprofessional team at the bedside. Students utilized communication tools such SBAR for interprofessional communication.
Patel, 2018	Evaluation of pharmacy students' knowledge and perceptions of pharmacogenetics before and after a simulation activity.	3-year PS in the four-year Doctor of Pharmacy (PharmD) (n=113)	Double-sided mirror to view and hear the live encounter outside the room. Prior the simulation, students complete a non-randomised, voluntary, anonymous pre-simulation assessment.	knowledge (multiple-choice questions), perceptions of individual ability to interpret and provide drug therapy results (Likert scale questions)	pre-post survey	SiP	SP	Clinical scenario involving a patient with acute coronary syndrome (coronary intervention with stent placement). Each team taking the lead on counselling the SP to explain why the pharmacogenetics test was ordered, what the test result meant, and how the test result would impact the selection of antiplatelet therapy.

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Paterson, 2015	Inter-professional prescribing masterclass for medical students and non-medical prescribing students (nurses and pharmacists): A pilot study.	4-year MS, pharmacist independent prescribing students, nurses prescribing students, 2 simulated patients, (n=10)	Medical students learn to prescribe at an undergraduate level while non-medical prescribers and pharmacist prescribers can gain extra skills in prescribing post-registration.	perceptions, attitude toward IP collaboration (RIPLS), confidence (validated self-efficacy score), trust in healthcare professional (trust in physician scale)	post activity assessment	H	IPR and SP	Students worked together to formulate and implement an evidence-based prescription. 3 cases which would be encountered in the practice were designed: (1) sepsis required antimicrobial treatment; (2) polypharmacy, uncontrolled hypertension; (3) community based-case, confusion secondary to multiple medication.
Planas, 2008	A systems approach to scaffold communication skills development.	Students in 3-professional year of the Doctor of Pharmacy curriculum.	A communication skills development (CSD) system included various types of learning activities and feedback processes (sections with SP). Each student was assigned to a laboratory session. SP actors received a training session before each set of interviews.	communication skills (faculty, patient, self and peer assessments to recognise communication strengths and areas of improvement)	post activity assessment	SiP	SP	Students received interview criteria to assess their performances (active listening, empathy, communication barriers, constructive feedback, patient-centered communication). Students completed the interview, wrote a SOAP note based on the encounter, and received verbal feedback from their patient.
Popkess, 2017	Interprofessional error disclosure simulation for health professional students	3-year dental students (n=49), 3-year PS (n=79), senior-level NS (n=74), (n=202)	Students were required to review a video on error disclosure prior to the simulation. 48 interprofessional teams, consisting of 4 to 5 members of each simulation. The standardised family member roles were portrayed by 8 students selected from the theater department. Simulation required 2,25 hours.	IPE, knowledge (10-item created by investigator), attitude about error disclosure (11-item 5-point Likert scale adapted pre-post evaluation, feedback evaluation)	pre-post survey	H	IPR and SP	Each IP team participated in one disclosure simulation and observed 2 other teams where the standardised family member reacted in a relieved, angry, or sad/distrustful affect. Simulations were followed by an IP faculty-facilitated debriefing (comparison among the teams and the different standardised family member affects).
Powers, 2019	Implementation of an active-learning laboratory on pharmacogenetics.	3-year PS (n=130)	active-learning laboratory session in a 1-credit course. 50-min lecture on clinical pharmacogenetics before laboratory (interpretation of a genetic profile in terms of CYP450 enzyme polymorphism)	knowledge (pre-post lecture, post laboratory multiple-choice questions on pharmacogenetics), confidence in pharmacogenetic counselling (pre-post lecture, post laboratory confidence survey)	pre-post survey	SiP	RP	Clinical case scenario and patient genetic profile to counsel a simulated patient played by an advanced pharmacy practice experience student or a graduate teaching assistant. Feedback on communication competencies given using a rubric.

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Quesnelle, 2018	Interprofessional education through a telehealth team-based learning exercise focused on pharmacogenomics.	1-year MS (n=67) and 3-year PS (n=23)	TBL IPE activity designed to serve a 2-hour stand-alone exercise within each curriculum. The application exercise was initially presented in the large group setting via PolyCom conferencing.	IPE attitude toward physician-pharmacist Collaboration (SATP2C), PGx confidence (2 additional specific questions)	pre-post survey	H	IPR and patient chart/case	Medical and pharmacy students conducted separate class exercises. The pharmacy student class exercise focused on analysis of pharmacogenomic data that may aide in predicting the response to narcotics. After, small groups teach each other about the diagnosis, comprehensive treatment plan, and recommendation for narcotics in this patient based on pharmacogenomics and simulated map data. Debriefing in large group using PolyCom conferencing.
Ragucci, 2014	Student evaluation of a clinical assessment course and related interprofessional simulation exercises	3-year PS (n=75), 3-year MS (n=36), 2-year NS (n=36), 1-year PAS (n=36)	2-week IP simulation experiences in a clinical assessment course	IPE perceptions (student feedback from 4 different professions, online anonymous simulator center survey, instructor evaluation), OSCE	post activity assessment	H	IPR and HPS	Teams of 5 and, 10 minutes to review 2 patient cases: (1) gastrointestinal bleed due to incorrect use of anticoagulants along with the use of non-steroidal anti-inflammatory medications, (2) sepsis and arrhythmia. The pharmacy student performed a medication history. After, the facilitators go back to debrief the students.
Ragucci, 2016	Evaluation of interprofessional team sisclosure of a medical error to a simulated patient.	3-year PS (n=75), 4-year MS (n=36), PAS (n=18), NS (n=18)	Simulated IP rounding experience of a medication error with a duplication of anticoagulation therapy. 10 minutes to review the chart before simulation. Faculty facilitators assigned to each room and followed the same script. One facilitator played the role of the patient.	IP team disclosing error to patient (validated rubric post simulation), satisfaction with IP communication	post activity assessment	H	IPR and HPS	IP simulation to recognise the duplication of anticoagulation therapy based on the medication list and patient history and disclose the error at hospital discharge. 30 minutes to stabilise and treat the patient, 10 minutes to provide discharge counselling and 10 minutes to debrief.
Rao, 2011	Skills development using role-play in a first-year pharmacy practice course.	1-year PS (n=130 in term 1, n=129 in term 2)	Instructors RP patient and pharmacist to show the roleplay process. A debriefing session held after the demonstration. Term 1: each group member played each one of the roles for each case. Term 2: each student assumed different roles for different cases. Group discussion	verbal communication, information gathering-skills, perceived usefulness of the model (term 1 and term 2 survey assessments)	post activity assessment	SiP	RP	Students performed different roles, including that of a pharmacist and a patient, and documented case notes in a single interaction.

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			and feedback at the end of each interaction.					
Ray, 2018	Retention of students' ability to incorporate a computer into simulated patient encounters.	2-professional year PS (n=166), n=82 from the 2016 class and n=84 from the 2017 class	PS (2 cohorts) completed the laboratory series courses. Patient encounters were video recorded, interactions were timed.	performance (blinded computer use skills rubric), awareness and confidence using computers	pre-post survey	SiP	SP	Individual encounter with a SP in a primary care clinic or emergency department, students gathered medication lists from or performed pharmaceutical care assessment. Interactions were timed (15-20 minutes per encounters). They developed and delivered pharmacotherapy plans to their patient or another health care provider.
Ray, 2017	Assessment of students' ability to incorporate a computer into increasingly complex simulated patient encounters.	3-year PS (n=78)	PS received specific instructions on effective computer use during patient encounters.	Students were evaluated by instructors on their ability to effectively incorporate a computer into a SPE using a rubric.	pre-post survey	SiP	SP	Increasingly complex simulated patient encounters: 15 minutes to gather a medication list to a cooperative simulated patient, but who expressed anxiety and sadness. After the simulation, 15-minutes of specific instruction on how to incorporate a computer into a patient encounter. In the last simulation, the simulated patient was taking 2 medications as needed and was uncooperative, agitated, and reluctant to give information.
Rickles, 2009	The impact of a standardized patient program on student learning of communication skills.	2-year PS (n=127)	Lecture-laboratory course on student communication skills. PS were assigned to 5 standardised patients 60-80 minutes. Pre-laboratory assignments included a review of the communication topics.	patients encounter self-assessment (Communication Skills Assessment Form CSAF)	blinded retrospective analysis	SiP	SP	5 PS met the SP for 7 minutes. After, they watched their tapes and self-assessed their encounter using the CSAF. Scenarios topics included learning how to listen, showing empathy, communicating with confused/aggressive/non-adherent patients, and using motivational techniques.

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Rivera, 2018	Integrative health: An interprofessional standardized patient case for prelicensure learners.	3-year dentistry, physical therapy, MS, 2-year nurse practitioner students, 4-year PS, SWS and nutrition trainees (n=520)	Classroom-based sessions before ISPE. 3-hours 15-min ISPE: students worked in IP teams of 4-5 learners, members discussed case information, interviewed the SP individually, joined a care plan of the SP. Debriefing with a facilitator.	ISPE collaboration-related behaviors, communication skills (Student Feedback Form, Student ISPE Evaluation Form)	post activity assessment	H	IPR and SP	SP interviewed individually while the other team member observed in encounter room (10 minutes per interview, 5 minutes break). During the break, SP completed the Student Feedback Form. Each interprofessional team met a faculty facilitator to present their plan briefly and discuss the interprofessional experience (35 minutes).
Sales, 2013	A comparison of educational interventions to enhance cultural competency in pharmacy students.	2-year PS (n=108)	3 educational interventions: (1) lecture on cultural competence and 2 patient cases. (2) lecture providing some background on cultural competence and written case (3) a simulation-patient activity	cultural assessment survey	pre-post survey	SiP	RP	The simulation group received a brief lecture providing some background on cultural competence and then was split into groups for 2 SiP encounters in which one student interviewed a patient non-Caucasian background, played by pharmaceutical sciences graduate students.
Schultz, 2007	Community-based collaboration with high school theater students as standardized patients.	3- and 4-professional year PS (n=75)	High school theater students portrayed patients in a laboratory during 2 consecutive years. Special make-up effect in the first-year cohort. 6 patients' rooms that are each monitored by a video camera. PS completed 1 encounter.	perceptions, effect of simulation with high school theater students on clinical skills (quantitative analysis for PS), qualitative analysis for theater students, semi-structured interviews	mixed method	SiP	RP	Realistic improvisation and patient centered care in triage encounters. Ambulatory care cases including cough and cold, infected wood splinter, suspected pregnancy, dog bite, minor burn, dermatologic cases (atopic dermatitis, psoriasis), smoking cessation.
Schwindt, 2018	Training future clinicians: An interprofessional approach to treating tobacco use and dependence.	NS (n=13), SWS (n=14), PharmD PS (n=9)	IP tobacco education programme: all participants completed 6 hours of training (a 2-hour web-based module, a 3-hour classroom training, a simulation with a SP, a group audio recorded debriefing session with faculty)	ICCAS, DML	mixed method	H	IPR and SP	Brief patient history before starting. 15 min tobacco cessation counselling simulation with varied SP. Students paired with a peer from a different profession for a cross-discipline consultation. Faculty-facilitated post-simulation debriefing session with all students together guided by the DML method.

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Seghal, 2019	First do no 'pharm': Educating medical and pharmacy students on the essentials of medication management.	2-year MS (n=60) and volunteers 2, 3 and 4-year PS (n=8)	polypharmacy simulated patient, flipped classroom and IPE with a SP	thematic analysis (ATLAS, vivo)	post activity assess ment	H	IPR and SP	2 parts in an IPE activity. (1) PS simulated the patient in a polymedication pillbox exercise (2) IP medication reconciliation exercise with a SP. MS portrayed the physician and PS portrayed a community pharmacist (participating by phone). Students preformed a medication reconciliation.
Serag-Bolos, 2018	Enhancing student knowledge through a comprehensive oncology simulation.	3-year PS (n=109)	16 teams (n=5-6 students) rotated in 3 stations in a chronological order: (1) to complete a detail order set for chemotherapy, (2) SP counselling on chemotherapy, (3) chemotherapy preparation. Debrief session after simulation.	knowledge, perceptions regarding pharmacists' roles in the oncology setting (anonymous voluntary pre-post assessment using Qualtrics peer reviewed by core faculty)	pre-post survey	SiP	SP	SP case (station 2) involved a 56-year-old-female with newly diagnosed ovarian cancer who had undergone surgery prior chemotherapy initiation. Students provided education on ovarian cancer for 20 minutes (prognosis the chemotherapy schedule, expectations and side effects of the chemotherapy regimen, appropriate supportive care medications).
Serag-Bolos, 2017	Assessing students' knowledge regarding the roles and responsibilities of a pharmacist with focus on care transitions through simulation.	3-year PS (n=51) with community pharmacy work experience	2 simulations assessments, one simulation each term. Patient cases utilised electronic medical records (EMR). The class was divided into 10 academic groups, each consisting of 5-6 students, to rotate through the stations.	knowledge, perceptions of pharmacist roles in TOC (anonymous assessment of knowledge before and after simulation each term)	pre-post survey	SiP	SP	Heart failure and atrial fibrillation cases. Same tasks for each simulation. Cases included all aspects of a patient chart such as demographics, vital signs, allergies, medication list, medication administration records, discharge notes. Each simulation day entailed a four-hour class period. Debriefing sessions after the simulation.
Shaikh, 2020	Assessing self-perceived interprofessional collaborative competency on advanced pharmacy practice experiences through interprofessional simulations.	4-year PS (n=157), MS, NS, dental hygiene, physical therapy, PAS	SP actors trained prior the simulation. PS collaborated with at least one student prescriber (NS, dental hygiene and/or physical therapy student). Each simulation included preparation work before simulation.	ICCAS	pre-post survey	H	IPR and RP	Case 1: Patient with dementia, depression, and constipation. Case 2: Non-adherence to diabetes regimen due to adverse reactions. Case 3: Homeless patient who suffers from alcohol use disorder.
Sharder, 2015	Incorporating standardized colleague simulations in a clinical assessment course and evaluating the impact on	4-year doctor PS (n=171)	Active-learning strategies with lectures and laboratory sessions. Prior the standardised colleague simulation, students are required to view a 60-minutes recorded	attitude toward IPC (survey instrument), communication skills, clinic performance (OSLE)	pre-post survey	H	IPR and SHP	2 simulations were inpatient and outpatient setting where students used the SBAR communication tool to deliver recommendations to a standardized colleague (anticoagulation clinic who needed warfarin and atrial fibrillation).

Reference	Title	Population	Settings	Assessment	Study design	Simulation modality	Type of simulator	Scenario design/activity description
	interprofessional communication.		lecture, included SBAR demonstrations.					10 minutes of simulated rounds and 10 minutes debriefing.
Sharder, 2014	Multiple interprofessional education activities delivered longitudinally within a required clinical assessment course.	3-year PS (n=71), MS NS and PAS	Separate activities using various strategies and simulated patients. Two-part hybrid simulation that used a human-patient simulator mannequin (part 1) and standardised patient (part 2). In part 2, students teams developed a TOC from hospital discharge and communicated a plan to the patient.	Interdisciplinary Education Perception Scale (IEPS)	pre-post survey	H	IPR, HPS, SP	Part 1: students applied TeamSTEPPS to an attending physician in simulation using human-patient simulation mannequins. Part 2: students teams participated in a home-visit to a geriatric patient to interview the patient and conduct a medication assessment.
Sharder, 2013	Interprofessional teamwork skills as predictors of clinical outcomes in a simulated healthcare setting.	4-year MS (n=25), 3-year PS (n=76), 1-year PAS (n=19); (n=120)	IP teams to manage a "*patient*" in a health care simulation setting. Each team encounter was video recorded. Formative evaluation.	teamwork performance (TWS Teamwork Score based on TeamSTEPPS observation tool), IEPS	post activity assess ment	H	IPR and HPS	IPR and and high-fidelity mannequin (patient). Team discussion based on a patient's medical record. Team cared for the simulated patient during a hospital rounds (to conduct a patient interview and physical examination, to order tests and medications), to observe vital signs. Teams were allotted 20 minutes to stabilise and treat the patient before debriefing.
Sharder, 2016	Using communication technology to enhance interprofessional education simulations.	4-year doctor PS (PharmD, n=163)	Applications-based capstone course. Students were randomly assigned to an IPE simulation with other health professions students using communication method such as telephone, e-mail, and videoconferencing.	ATHCTS, satisfaction (written reflection papers)	mixed metho d, pre-post survey	H	IPR and patient chart/case	3 simulations: (1) SBAR simulation included nursing and pharmacy students collaborating on a variety of patients scenarios; (2) MTM included medical and pharmacy students following a patients' discharge from the hospital; (3) TOC simulation included IP students' teams consisting of dietetics, nurse practitioner, occupational therapy, and pharmacy students.

Reference	Title	Population	Settings	Assessment	Study design	Simulation modality	Type of simulator	Scenario design/activity description
Sharder, 2011	A simulated interprofessional rounding experience in a clinical assessment course.	3-year PS (n=77), 3-4-year MS and 1-year medical assistant (n=37)	IP rounding experience using HPS. 22 IP teams were assigned 1 time slot (75 min) during 3 laboratory days. Students provided comprehensive medical care in an inpatient setting. An instructor explained objectives and HPS function 15 min orientation. After, teams reviewed the medical chart.	attitude toward IPC (survey instrument), performance (clinical outcomes checklist)	mixed metho d	H	IPR and HPS	Medication error/interaction scenarios: gastrointestinal bleeding related to warfarin or a patient with digoxin toxicity and related cardiac arrhythmias. Students conducted a patient interview and physical examination, ordered laboratory, diagnostic and medication. The IP team had 20 min to stabilise and treat the patient; then faculty debriefed students about simulation (20 min).
Sincak, 2017	Transformation of an online multidisciplinary course into a live interprofessional experience.	PS (n=212), osteopathic MS (n=190), dental medicine (n=130), PAS (n=83), physical therapy (n=55), occupational therapy (n=50), speech and language pathology (n=41), clinical psychology (n=22); (n=783)	Lectures to the entire class in a large auditorium. After, students were divided into 5 sessions of 160 students. Sections were subdivided into small teams of 5 for the SP encounter.	IP skills, team dynamic (SP checklist), students' perceptions on IP knowledge, skills, and attitude (IPE course survey questions)	post activity assess ment	H	IPR and SP	The team had 25 minutes to interview the SP as a group. The SP also provided verbal feedback and completed a checklist about the team's interprofessional skills and group dynamics. After the interview, the small teams worked together to answer a series of questions that focused on the different roles of each profession played when taking care of the patient.
Singla, 2004	Interdisciplinary approach to teaching medication adherence to pharmacy and osteopathic medical students	3-year PS (n=92), 2-year osteopathic MS (n=115)	MS paired with PS. Pharmacy counselling interventions: A (script material, counselling, and placebo medication), B (group A intervention and a postcard mail reminder sent after 2 weeks), C (group A intervention and counselling session after 2 weeks of therapy), D (MS control group)	medication adherence skills (medication adherence assessment), IPE perceived attitude (attitudinal survey)	post activity assess ment	H	IPR and RP	Needlestick exposure and HIV prophylaxis for a physician (played by a medical student). PS provided medication education on the placebo HIV prophylaxis regimen (Tic-Tac's as placebo). After 4 weeks, all groups met for a medication adherence session. Students worked together to identify barriers to medication adherence and possible solutions to these barriers.

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								After, post session discussion to review issues learned from the project.
Smith, 2019	Collaborating to care for a standardized patient in the outpatient setting: An interprofessional learning activity for dental and pharmacy students	2-year PS (n=226), 4-year dental students (n=68)	Online tool to discuss roles/responsibilities of their professions with their team members prior the IPLE. IP teams of 6 pharmacy students and 3 dental students.	JEFFSATIC, RR quiz	pre-post survey	H	IPR and SP	Teams interviewed a medically complex SP presenting with acute dental. Students collaboratively discussed therapeutic options and developed a treatment plan. The SP case was a patient with atrial fibrillation, diabetes, hypertension, and periodontal disease who presents with acute dental pain for an interprofessional visit at a free clinic.
Smith, 2020	Incorporating the pharmacists' patient care process into an interprofessional second year capstone.	2-year PS (n=230 in 2017, N=265 in 2018) and dental students (n=68 in 2017, N=90 in 2018)	IP teams (6 pharmacy, 2 dental students). PPCP to provide a framework for consistent delivery pharmacy services across continuum of care.	JeffSATIC and RR quiz	post activity assessment	H	IPR and SP	Pharmacy students collaborated with dental students to collect information from a SP, assess dental and pharmacy-related problems, and develop a plan (using PPCP) resolving the problems identified. Students documented a SOAP note and followed up with the SP after an emergency room visit.
Smithburger, 2013	Advancing interprofessional education through the use of high-fidelity human patient simulators.	PS, MS, NS, social work, and PAS (n=8)	1-day a week for a 4-week period, students work together to complete complex simulation scenarios in small IP teams.	CATS assessment	post activity assessment	H	IPR, HPS, RP	4 TOC simulations scenarios from emergency department (HTA crisis and bacteremia). Students assumed their roles and interacted with a faculty member who was playing the role of the patient's daughter. The debriefing session provided immediate feedback that allowed the students to reflect on their performance and apply new skills to the next simulation scenario.
Southall, 2021	Fostering undergraduate medicine, nursing, and pharmacy students' readiness for interprofessional learning using high-fidelity simulation.	senior undergraduate MS (n=9), NS (n=11), and PS (n=4), (n=24)	24 students in 7 IP teams. Each team participated in a high-fidelity interprofessional education module designed to teach the clinical management of an adult patient experiencing acute anaphylaxis.	RIPLS	pre-post survey	H	IPR, HPS, SP	30-min briefing session, 1-hour clinical simulation, 30-min debriefing session. Care of a patient experiencing acute anaphylaxis. Students had access to a chart containing the patient's admission history and medication administration records. As the simulation progressed,

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								the patient deteriorated and the team managed care including the administration of a bolus of epinephrine and cardiac monitoring.
Stehlik, 2018	Effect of hospital simulation tutorials on nursing and pharmacy student perception of interprofessional collaboration: Findings from a pilot study.	final year PS (n=68), and NS (n=58)	Scenario-based patient care in a simulated environment. The sessions were conducted over a 5-week period in weekly 2-hours sessions (admission of the patient to discharge).	IEPS score	pre-post survey	H	IPR and HPS	1) provide a medical chart review to a medium fidelity mannequin admission review and to hand over recommendations to the NS. 2) to provide discharge counselling to a patient.
Stewart, 2013	Student self-assessment of knowledge and application of legal concepts in a community pharmacy simulation	1-professional year PS (n=43)	Community pharmacy setting (counselling room and pharmacist workstations equipped with a computer to enable interaction with patients). Each pharmacist was assigned to one of the workstations along with a support staff, which included one pharmacy intern, two technicians and one technician candidate.	pre- and post-assessment on confidence and knowledge of legal requirements, faculty observation, post-simulation questionnaire	pre-post survey	SiP	RP	Simulation in a realistic community pharmacy environment in which practitioners are forced to multi-task. Students role-played as pharmacists, technicians, interns in a series of 10-minutes simulations. Students in the role of pharmacist were challenged with several violations that they would have recognised.
Suematsu, 2018	A Scottish and Japanese experience of patient-centered diabetic care: descriptive study of interprofessional education on live webinar.	5 and 6-year MS (n=3), 5-year PS from Japan (n=4), MS, PS (n=2), nutrition and occupational therapy student (from Scotland).	A case-based scenario that reflected diabetes care was developed in each country. The same virtual learning environment was used in both the countries: Blackboard Collaborate.	IEPS	pre-post survey	H	IPR, VE, SP	International IPE with SP in a live webinar. The case-based scenario reflected diabetes care in each country. SP interviewed in each country. Exchange care methods for the SP: each national team presented their diabetic care plan, and all students discussed the diabetic car plan online.

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Suematsu, 2021	A novel online interprofessional education with standardized family members in the COVID-19 period.	MS (n=44), NS (n=40) and PS (n=16)	Online IPE with asynchronous self-study using online videos and synchronous online discussion modalities that enable real-time participation. 3 sessions: clinical scenario focusing on an older population with diabetes and dementia, profession's role discussion and interview of SFM. 2 mixed professional groups.	SFM gave feedback from SFM, satisfaction (student's reflections)	post activity assessment	H	IPR and SP	Teams of medical, nursing and pharmacy students interviewed an SFM (because the patient setting in the scenario was people with dementia) whose mother-in-law was hospitalised for treating diabetes. SFM acted as family members who lived with the scenario of a patient with dementia. SFM were interviewed by students and gave to them feedback to promote reflection.
Tallentire, 2021	Exploring transformative learning for trainee pharmacists through interprofessional simulation: A constructivist interview study.	pre-registration pharmacists (n=15), MS	Exploration of the impact of an immersive IPE simulation scenario on transformative learning (Mezirow's phases)	semi-structured interview based on the transformative learning framework; transcripts analysed with Mezirow's phases of perspective transformation forming the initial coding template.	constuctivist study	H	IPR and HPS	PS paired with MS in 15-min scenario (a simulated environment consisted of a mannequin simulator). Post-scenario debriefs focused on teamworking. Participants were interviewed after simulation session, using a semi-structured interview schedule based on the transformative learning framework initial coding template.
Terriff, 2017	Training student pharmacists to administer emergency pediatric influenza vaccine: A comparison of traditional vs. just-in-time training.	3-professional year PS (n=50)	Briefing about mass vaccination. Traditional training (TT) and just in time training (JITT) comparison.	interest, comfort, and confidence in ability to administer a pediatric vaccination	pre-post survey	H	IPR, SP, manikin	During a fictional H7N9 influenza pandemic, PS were needed to provide influenza immunisation at a mass vaccination clinic. They provided vaccination to a child manikin who may require a different dose and injection site.
Thakur, 2020	Pharmacy studentopioid consultations with standardized limited english proficiency patients.	3-year PS (n=23)	5 min to review patient profile/drug information prior consultation. No instructions about opioid topics. Consultations video recorded. Coding protocol analysis.	verbal and non-verbal communication skills (structured coding tool)	observational and descriptive study	SiP	SP	SP who spoke 30% English and 70% non-English language with a prescription for oxycodone for severe pain.
Thomas, 2021	End of life simulation to improve interprofessional competencies: A mixed methods study.	PS, physical therapy, NS (n=320)	2-hour low-fidelity, RP simulation focused on end-of-life (EOL). Students were assigned to one of 4, replicated, IP simulations across two 16-weeks terms.	perceptions of IPE and skills (Interprofessional Socialisation and Value Scale)	mixed method, pre-post survey	H	LFM, RP and IPR	5-8 members IP teams (2 students of each team played the role of a patient with a terminal disease). "*Palliative care team meeting*" for 30 minutes, patient's goals listening and establishing the team care plan. After the simulation, IP faculty med a 20-min class debrief.

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Tilley, 2021	Real-time, simulation-enhanced interprofessional education in the care of older adults with multiple chronic comorbidities: a utilization-focused evaluation.	advanced practice NS (NP) and Doctor of PS, n=96	2 HPS-enhanced IPE (Sim-IPE) implemented to assess IP competencies in simulations involving patients with chronic cardiovascular disease.	ICCAS, satisfaction	post activity assessment (impact survey)	H	IPR and HPS	Students conducted a patient health history and collected pertinent medication information relevant to the chief complaint (20 minutes) and developed a comprehensive treatment plan (30 minutes). IP teams presented their diagnosis, proposed treatment plan, and educated the SP on his/her medications. PEARLS debriefing.
Tremblay, 2018	Simulation-based crisis resource management in pharmacy education.	undergraduate PS (70%) and pharmacy technician students (30%), n=202	Scenarios of various complexity level targeting different CRM principles. 2 simulation technicians orchestrate the technical aspects of the scenarios (10-15 minutes). A pharmacist who has received training on debriefing techniques and CRM principles accompanies each group.	satisfaction and perceptions	post activity assessment	H	IPR and patient chart/case	Teams of 6-9 students, 3 scenarios required the participation of 4 students (other students observed the simulation). Each participant contributed to the 30-min debriefing per case (Debriefing with Good Judgement).
Tremblay, 2017	The simulated clinical environment: Cognitive and emotional impact among undergraduates.	4-year (PharmD) PS (n=143)	SCI and SP in a crossover design. After each debriefing period, participants completed a questionnaire (cognitive load, self-perceived learning, emotions associated with the simulation and an appreciation of both SCI and SP). Focus groups to explore their perception of learning in simulation.	cognitive load, self-perceived learning, emotions associated with the simulation and an appreciation of both SCI and SP	mixed method	SiP	SP or SCI	Participants experienced both SP and SCI in a crossover sequence. Participants played different roles in rotation during simulation sessions (pharmacist, SiP, and observer). The main difference between SP and SCI is the interactions with the physical environment (telephone and medication were not available with SP).
Tremblay, 2019	Simulation-based education for novices: complex learning tasks promote reflective practice.	2-year PS (n=167)	Students were randomly assigned to groups of 3-4 students to undertake one simple and one complex learning task in SCI consecutively. Semi-structured interviews were conducted.	cognitive load and task performance	mixed method	H	SCI and RP	The simulation started with a short briefing exposing overall objectives. 2 consecutive SCI learning tasks: one simple and one more complex (10-15 min per case) followed by the respective debriefing (15-25 min). Other participants observed student's simulations and listed actions executed by the pharmacist using a checklist developed for each task.

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Ulutaş Deniz, 2018	Feedback for a simulation practice on communication skills in pharmacy education: A pilot study	2-year pharmacy technician students (n=22) and 3-year PS (n=4)	6 scenarios were used and recorded. 4 SP were trained to portrayed different patients.	written feedbacks for a thematic analysis	post activity assessment	SiP	SP	Scenarios were randomly assigned to the students (antibiotic use, drug abuse, preparation of magisterial drug, tobacco use, patient privacy). Each student was asked to interview with the patient for 5 minutes. Performances were recorded. At the end of the debriefing sessions, students were asked to provide written feedback.
Victor-Chmil, 2016	An interprofessional simulation for child abuse reporting	NS (n=55), 3-year Doctor of PS (n=74), (n=129)	A Child Abuse Reporting Interprofessional Simulation-Based Experience (CAR-IBSE) was an online training for undergraduate pharmacy and NS. Scenarios exposed students to a realistic yet safe situation in which child abuse reporting is mandatory.	simulation evaluation, perceptions (online post simulation survey, Likert Scale)	post activity assessment	H	IPR, LFM, SP	CAR-IBSE included planning, performing and debriefing stages (20 minutes each). 2 medication diversion scenarios: (1) home environment with a narcotic medication that was being diverted from the client (grandmother played by a SP) was being taken by the client's daughter (not present during the scenario), (2) and walk-in clinic setting in which a new single mother who was breastfeeding her 7-week infant (LFM).
Vyas, 2012	Patient simulation to demonstrate students' competency in core domain abilities prior to beginning advanced pharmacy practice experiences.	PS (n=28)	60h of IPPE to provide clinical experiences. Assessment of core domain abilities in APPE. Control group.	Perception of Preparedness to Perform (PREP) survey), knowledge, APPE core domain abilities	pre-post survey	SiP	SP	Students were divided into 10 teams of 2 to 4 students each. Prior simulation, students were given treatment guidelines or readings to prepare the scenario. Simulation experience was divided into 3 sections of 30 minutes (case preparation, patient encounter, debrief session).
Vyas, 2018	Training students to address vaccinehesitancy and/or refusal.	PS (n=203)	Before the learning unit, students complete an Immunisation Training Certification programme. 2 SP encounters performed 1 week apart. Faculty members developed the scenarios and scripts for the SP based on vaccines myths. A conflict escalation was put into each script.	knowledge, confidence (attitude survey prior and post simulation), communication skills, social, emotional competence (SP grading rubric), satisfaction (post survey)	pre-post survey	SiP	SP	The scenario was vague as students were expected to evaluate the patient by asking questions, providing counselling, mediating any conflict, and maintaining the patient-provider relationship despite possible disagreements. A conflict scenario would be triggered if the SP felt the pharmacy student was not listening, not being properly empathetic or exhibiting a condescending or dismissive attitude.

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Vyas, 2012	An interprofessional course using human patient simulation to teach patient safety and teamwork skills.	PS (n=23), MS, NS, health administratio n (n=210)	Groups of 10-12 health professions students that included 1-2 pharmacy students. 5 patients' cases were developed using a combination of SP, HFS and hospital staff members, including resident physicians.	pre-post simulation survey of knowledge, skills, and attitudes	pre-post survey	hybrid	IPR and RP	5 semi-urgent situations that required interprofessional collaboration (pregnant patient with teratogenic medication, baby with a head trauma, asthmatic patient, wrist pain and allergy to morphine, chest pain). 20 minutes for each scenario. Debriefing session following the simulation.
Wagner, 2021	Activities to enhance introductory pharmacy practice experiences.	3-year PS (n=36)	Instruction on the approach to clinical evaluation of a patient: a live real-time internal medicine (IM) or infectious disease (ID) service, and a group discussion related to the patient case; IP (rounding experience) during combined IM and ID.	patient communication, rounding interactions (standardised rubrics), knowledge, confidence (examination questions)	pre-post survey	SiP	SP	Simulated electronic health record prior the simulated rounding activity. Students completed a medication reconciliation and allergy assessment with the SP. Students presented their patent's assessment physician, including diagnoses and pharmacotherapy recommendations. The physician examined and evaluated the SP. Following completion of rounds, the students provided discharge counselling to the SP.
Wang, 2020	Use of profession-role exchange in an interprofessional student team-based community health service-learning experience	20 MS, 20 PS and 20 NS (n=60)	Students randomly divided into the profession-role exchange intervention group and the control group. Each group was composed of 10 students of each profession. Control group did not participate the profession-role exchange experiences.	attitudes toward IP clinical collaboration, role clarification (Roles and Responsibilities subscale of RIPLS)	pre-post survey	H	IPR and real patient	Teams (medical, pharmacy and NS) conducted household visits for the community residents suffering from diabetes, to educate them about diabetes self-management and address their healthcare needs. In the intervention group, the profession-role exchange experiences were a role-playing education game, in which healthcare students from different professions play one another's role in an environment like the clinical environment. Students in the intervention group were required to perform the responsibilities of the students from other professions.

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Wen, 2019	An interprofessional team simulation exercise about a complex geriatric patient.	MS (n=27), NS (n=49), PS (n=18), SWS (n=18)	Video of an IP team meeting and review of the case before IPE. Different disciplines were divided into groups representing teams. Pharmacy students attended the meeting remotely via videoconference from a neighboring island. 40-min debriefing after the simulation activity.	satisfaction (qualitative data), core competency domains (pre-post simulation questionnaire)	mixed method, pre-post survey	H	IPR and SP	The scenario was a simulation of a hospital discharge for an older adult with complex problems. Students collaborated to develop a discharge plan, followed by a simulated family meeting with a theater student. The scenario required the input and collaboration of all disciplines and touched many competencies.
Westberg, 2006	An interprofessional activity using standardized patients.	2-year PS (n=48), 2-year MS and 4-year NS	ISPE with social, environmental, and mental health components. Room with a one-way mirror for patient care events. After 1 hour SP scenarios, teams collaborate to develop a patient care plan. Pre- and post- experience surveys were conducted.	one-on-one feedback on the demonstrated skills/performance of the student by the faculty member	pre-post survey	H	IPR and SP	ISPE in which each student has time to interview the patient according to his/her own skills and patient care perspective. After assessment, the team collaborates to develop a patient care plan.
Willson, 2020	Training student pharmacists in suicide awareness and prevention.	PS (n=171)	Suicide prevention training programme. SP prescription counselling session was conducted 2 weeks after training session. Videos of the counselling sessions were reviewed to determine whether pharmacy students assessed the patient for suicide risks.	knowledge in suicide prevention (questions adapted from Suicide Prevention for Pharmacy Professionals training and Gatekeeper Training for Suicide Prevention Programme), ability to apply skills (summative assessment using a SP), reflections	mixed method, pre-post survey	SiP	RP	Students practiced incorporating Safer Homes messaging into patient prescription counselling and applied the LEARN framework to patient case scenarios using RP and group discussions.
Wong, 2021	From a distance: Nursing and pharmacy students use teamwork and telehealth technology to provide interprofessional care in a simulation with telepresence robots	2-year PS (n=84) and 2-year NS (n=37)	Students participated in a pilot telepresence robot simulation course. Multiple small group sessions were conducted to ensure students had an active role in one of the 2 scenarios. The course design included structured pre-work, icebreaker, patient encounter with virtual collaboration via telepresence robot, and debriefing.	ICCAS, students' feedback (qualitative assessment)	mixed method, post activity assessment	H	IPR and HPS	Pharmacy students and NS collaborated as an IP team via a telepresence robot, video teleconferencing, and telephone. During the simulation, nursing student (Campus A) collaborated with pharmacy students (Campus B) via telepresence robot to manage the care of a patient (high-fidelity manikin). Facilitators led debriefing sessions after each scenario using video teleconferencing cameras for video and telephone to connect Campus A and B.

Reference	Title	Population	Settings	Assessment	Study design	Simulation modality	Type of simulator	Scenario design/activity description

Abbreviations: ATN-addiction training for nurses ATN; APPE-advanced pharmacy practice experience; ASES-aging simulation experience survey; AOI-area of improvement; AFA-asthma first aid; ATHCTS-attitude toward healthcare teams scale; ATTS-attitudes towards suicide scale; CATS-communication and teamwork skills; CSAT-center of abuse treatment; CAR-IBSE- child abuse reporting interprofessional simulation-based experience; CSAF-communication skills assessment form; DML-debriefing for meaningful learning; EXCELL-excellence in Cultural Experiential Learning and Leadership; FOC-frequency of care; HFS-high fidelity simulation; HPS-human patient simulator; IEPS-Interdisciplinarity Education Perception Scale; IP-interprofessional; IPAS-Interprofessional Attitudes Scale; IPC-interprofessional collaboration; ICCAS-interprofessional collaborative competency attainment survey; IPEC-interprofessional education collaborative; IPE-interprofessional education; IPR-interprofessional role-play; ISPE-interprofessional standardized patient case; ISPE-interprofessional standardised patient experience; IPPE-introductory pharmacy practiced experience; IPL-interprofessional learning; IPLE-interprofessional learning experience; JeffSATIC-Jefferson scale of attitude toward interprofessional collaboration; JSE-HPS-Jefferson scale of empathy-health professions scale; JSPE-Jefferson scale of physician empathy; KCES-Kiersma-Chen empathy scale; LEARN-look for warning signs, empathise and listen, ask about suicide, remove the danger, next steps; LFM-low-fidelity manikin; MC-medication counselling; MHFA-mental health first aid; MRSA-methicillin resistant S. aureus; MS-medical student; MTM-Medication Therapy Management; NS-nursing students; OSCE-objective structured clinical examination; OSLE-objective structured learning experience; PAS-physical assessment student; PCA-patient case, PC-patient communication, PEARLS- Promoting Excellence and Reflective Learning in Simulation; PPCP-pharmacist's patient care process; PGx-pharmacogenomics; PS-pharmacy student; RIPE-reflective interprofessional education; SATP2C-scale of attitude toward physician-pharmacist collaboration; SBAR-situation, background, assessment, recommendation; SBIRT- screening, brief intervention, referral to treatment; SiP-simulated patient; SMaRT-SBIRT medical and residency training; SCI-simulated clinical immersion; SLMs-simulated learning modules; SBE-simulation based education; SBL-simulation-based learning; SDOH-social determinant of health; SIMs-Social Interaction Maps; SWS-social work student; SFM-standardized family members; SHP-standardized health care provider; SP-standardised patient, SPICE(-R)-student perceptions of physician-pharmacist interprofessional clinical education(-revised instrument); SOAP-subjective, objective, assessment, plan; TeamSTEPPS-team strategies and tools to enhance performance and patient safety; TBL-team-based learning; RIPLS-readiness for interprofessional learning scale; TL-transformative learning; TOC-transition of care; TSS-team skills scale; VE-virtual environment.

Pharmacy Education (2024) 24(1) 146 - 153
https://doi.org/10.46542/pe.2024.241.146153

RESEARCH ARTICLE

Does one size fit all? A survey of preceptor perceptions and experiences with remote rotations

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Keywords
Experiential learning
Pharmacy education
Preceptor
Remote
Virtual learning

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Abstract

Background: During the pandemic, experiential rotations transitioned from in-person to remote rotations. **Methods:** The authors surveyed preceptors about their experiences and perceptions on remote rotations. Preceptors completed an online questionnaire divided into six domains: 1) General demographics; 2) Preceptor/student relationship; 3) Preceptor support and continuing professional development opportunities, 4) Technology; 5) Preceptor perceptions; and 6) Motivators and challenges. Responses were coded and analysed for emerging themes. **Results:** A total of 47 out of 157 preceptors (30%) responded to the questionnaire and most preceptors were willing to precept remotely again (85%). Student responsiveness (87%) and enjoyment of teaching (83%) were the greatest motivators. Major themes reflected preceptor's struggles in building rapport and facilitating in-the-moment learning opportunities. Preceptors identified guidance and on-going support as key factors to ensure preceptor and student readiness, and to manage expectations. The formula for a successful rotation included careful consideration of appropriate pedagogy, technology, and a dose of motivation. **Conclusion:** Preceptors reflected a positive experience in leading remote rotations. Traditional precepting approaches employed during in-person rotations need to be adapted and individualised for the context of remote rotations, highlighting that there is no 'one-size-fits-all' approach. Transitioning to a remote environment generates new opportunities and drives innovation.

Introduction

Experiential education is essential for pharmacy students to develop key competencies and meet educational outcomes of the accredited Doctor of Pharmacy (Pharm.D.) programmes in Canada (AFPC, 2017). At the Leslie Dan Faculty of Pharmacy, University of Toronto, fourth-year students are required to complete 35 weeks of advanced pharmacy practice experience (APPE) rotations comprised of direct patient care (DPC) and non-direct patient care (NDPC) elective rotations.

In March 2020, the global COVID-19 pandemic necessitated that most pharmacy schools, including the Leslie Dan Faculty of Pharmacy, University of Toronto, suspend all DPC rotations. It was determined that NDPC rotations could continue safely as these could be precepted remotely. However, there was a paucity of guidance regarding how to do this effectively. Prior to the pandemic, studies specific to remotely precepted rotations were scarce and focused on the implementation of this model in areas with limited resources or in underserviced communities (Johnson, 2019; Weddle *et al.,* 2020). Subsequent studies focused primarily on the student experience with remote DPC rotations. Montepara and colleagues (2021) summarised the remote APPE experience in a large hospital health system. Students from four pharmacy schools completed a structured curriculum led by a pool of preceptors with a focus on clinical activities such as patient case discussions and drug information questions. A survey was administered to capture

student perspectives, and they reported positive experiences in learning from a variety of preceptors. Zhu and Brown (2021) also surveyed students to ascertain best practices for remote NDPC rotations from the student's perspective. They concluded that setting clear expectations and building a strong rapport with the student are key strategies that preceptors can employ for a successful remote rotation. Law and authors described addressing the shift to remote rotations by designing a calendar of mock clinical activities for students (Law *et al.,* 2021). The researchers also created a variety of resources for preceptors, such as a COVID-19 guidance document and virtual APPE playbooks to facilitate the achievement of rotation requirements during the transition to remote precepting. Kang-Birken and authors conducted a formal evaluation of these remote rotation activities. Although these were primarily DPC-focused activities, their evaluation specifically included preceptors' and students' perspectives (Kang-Birken *et al.,* 2022). Both students and preceptors expressed a desire to include remote activities in APPE rotations post-pandemic (Kang-Birken *et al.,* 2022). There was only one commentary that focused on a preceptor's experience in conducting remote NDPC research-focused APPE rotations (Hundal *et al.,* 2021). They described their challenges and proposed solutions in areas including maintaining communication and student engagement.

The global pandemic accelerated the necessity to precept APPE rotations remotely, but it is still a relatively novel approach. Most of the literature focuses on the student experience in remote experiential rotations. However, as part of continuous quality improvement, it is incumbent to find out what this experience was like for preceptors. Addressing this gap is key to determining if this mode of delivery is viable to continue in pharmacy experiential education. Thus, the primary objective was to understand preceptors' experiences and perceptions of remote rotations.

Methods

The authors adapted a survey that explored best practices in remote rotations from pharmacy students' perspectives (Zhu & Brown, 2021). Informed by a literature review of remote learning and precepting in the health disciplines, the authors focused the questions to include aspects relevant to precepting remote rotations, including preceptor preparation (Ho *et al.,* 2021), the preceptor/student relationship (Rand & Pajarillo, 2015), access to technology (Johnson, 2019), preceptor satisfaction and professional development needs (Ackman & Romanick, 2011).

The survey consisted of 39 questions grouped under six domains:

1. General demographics
2. Preceptor/student academic relationship
3. Preceptor perceptions
4. Preceptor support and continuing professional development (CPD) opportunities
5. Motivators and challenges
6. Technology use

Response choices included a mix of Likert-scale, multiple-choice, and open-ended questions. The survey was pretested by faculty members, preceptors and experiential education staff. Ethics approval was obtained from the University of Toronto Research Ethics Board (RIS Protocol Number 39827).

All preceptors (n=157) who remotely precepted at least one 5-week NDPC rotation during the first three blocks of the academic year (May–August 2020) were invited to participate. Informed consent was obtained prior to the completion of the survey. Microsoft Forms was used to administer the survey anonymously. The survey was open for a three-week period from mid-October to early November 2020.

Quantitative data was analysed using descriptive statistics. Four research team members (BL, GS, ABM, DK), independently coded responses to the open-ended questions and analysed the data for emerging themes and subthemes (Erlingsson & Brysiewicz, 2017). The researchers collectively considered the independently coded responses and emerging themes and resolved discrepancies through consensus. This collective and iterative process was used to refine categories and themes.

Results

Forty-seven preceptors (30%) responded to the survey, and 51% of respondents precepted two or more students remotely (Table I). In the three years prior, 66% precepted up to 10 students, and 31.9% precepted more than ten students in person. Preceptors worked from home (45.5%) or a hybrid of home/work environments (29.8%). The most prevalent types of NDPC rotations included project (27.7%), research (10.6%), education (8.5%) or a mix (38.3%).

Remote meetings were as productive as in-person meetings for a large majority of preceptors (78.7%). Forming a preceptor-student relationship during a remote rotation was more difficult compared to in-person rotations (51.1%). Preceptors reviewed

expectations on the first day (46.8%) or partway through the rotation (34.0%). Additionally, they allowed students to set flexible hours (80.9%), had a system to track student progress on assigned work (89.4%) and reported their students always or mostly met deadlines (97.8%). Formative feedback was provided a few times per week (51.1%), daily (27.7%) or weekly (21.3%).

Table I: Characteristics of preceptors and rotation types

Number of responses	n=47 (%)
Number of students precepted over three years (in-person and remote)	
1	5 (10.6)
2	2 (4.3)
3-10	24 (51.1)
>10	15 (31.9)
Choose not to answer	1 (2.1)
Number of students precepted remotely during study period (May-August 2020)	
>2	15 (31.9)
2	9 (19.1)
1	23 (48.9)
Current work setting	
Remote from home	23 (45.5)
Hospital	6 (12.8)
Community pharmacy	4 (8.5)
Hybrid (combination of home and work setting)	14 (29.8)
Types of rotations*	
Combinations of the below types	18 (38.3)
Project	13 (27.7)
Research	5 (10.6)
Education	4 (8.5)
Drug use evaluation/review	2 (4.3)
Drug/ medical information	2 (4.3)
Advocacy	1 (2.1)
Pharmacovigilance	1 (2.1)
Choose not to answer	1 (2.1)

*Participants had the option to choose more than one type of rotation.

In the area of support and continuing professional development, respondents agreed that they received adequate guidance from the Faculty regarding precepting remote rotations (61.7%). The majority (78.7%) attended at least one preceptor forum. However, preceptors cited schedule conflict (68.1%), being too busy (57.4%), and already being familiar with topics (29.8%) as top reasons for not attending sessions (Table II). Factors that increased motivation to precept were student engagement (87.2%), enjoying teaching (83%), progress on projects/assigned work (83%) and a good relationship with students (74.5%). In contrast, workload responsibilities (68.1%) reduced their motivation to precept students. Despite this, most preceptors were willing to precept remotely again (85.1%).

Regarding technology use, preceptors discussed with their students if they had reliable internet service and devices (80.9%). Preceptors communicated with students via email (100%), video conferencing (97.9%), text messaging (40.4%), phone (40.4%) and online messaging (25.7%). Challenges with communicating with students remotely included not being able to communicate in-the-moment (48.9%) and students (27.7%) or their own (19.2%) internet connectivity. Sharing confidential information was easy for about half of preceptors (44.6%).

Table II: Survey responses relating to continuous professional development, technology use and motivation domains

Domains	n=47 (%)
Preceptor support and continuing professional development opportunities	
Reasons that prevented attendance of preceptor forums ‡	
Schedule conflict	32 (68.1)
Too busy	27 (57.4)
Already familiar with topics	14 (29.8)
Topic not of interest	7 (14.9)
Not applicable	1 (2.1)
Motivation	
Factors that increased motivation to precept ‡	
Student engagement	41 (87.2)
Enjoy teaching	39 (83.0)
Progress on projects/assigned work	39 (83.0)
Good relationship with the student	35 (74.5)
Daily routine	17 (36.2)
Set work hours	14 (29.8)
Guidance/resources to precepting a remote rotation	9 (19.1)
Factors that reduced motivation to precept ‡	
Workload responsibilities	32 (68.1)
Lack of student engagement	6 (12.8)
Lack of daily routine	5 (10.6)
Poor relationship with student	5 (10.6)
Lack of progress on projects/assigned	4 (8.5)
Lack of set work hours	4 (8.5)
Technology use	
Frequency of video (face-to-face) feature use vs. audio only	
Always	33 (70.2)
Sometimes	7 (14.9)
Rarely	4 (8.5)
Never	2 (4.3)
I choose not to answer	1 (2.1)
Challenging aspects of communicating with students remotely ‡	
Not being able to communicate in the moment	23 (48.9)
Student's internet connectivity	13 (27.7)
My internet connectivity	9 (19.2)
None	6 (12.8)
Time zone difference	4 (8.5)
Finding a mode of communication	3 (6.4)
I choose not to answer	1 (2.1)

‡Participants had the option to choose more than one factor or aspect

The authors identified three major themes and several sub-themes from the qualitative analysis (Table III). The first major theme revealed remote precepting is not a "*one size fits all*" approach, as traditional approaches to rapport building and teaching are limited in this environment. Preceptors experienced difficulty building relationships with students and gauging their progress and understanding. These would traditionally be accomplished through informal conversation or spur-of-the-moment teaching encounters.

The second major theme illustrated the need for preparation and ongoing support to ensure readiness

and manage expectations. Preceptors expressed wanting support in teaching and precepting and assigning an appropriate amount and scope of work for the student. Respondents reflected that greater preparation is required for students and preceptors in a remote rotation. Many suggested creating a student community of practice for peer support.

The third major theme centred on the recipe for a successful rotation, which included technology, pedagogy, and a dose of motivation. Reliable internet connectivity and suitable equipment were essential to enable effective student-preceptor communication and sharing of confidential information. Preceptors commented that they needed to adopt different teaching strategies for virtual education, particularly for in-the-moment learning. Motivation to precept was driven primarily by the enjoyment of teaching, student engagement and completion of assigned work.

Table III: Major themes and sub-themes with representative participant quotes

Theme	Subthemes	Representative quote
Theme 1: One size does not fit all – Traditional approaches to rapport building and teaching are limited	Difficulty in building informal relationship	*"miss out on the casual interactions where you get to know the student better – i.e. getting coffee, walking to and from meetings together."*
	Gauging student progress and understanding is challenging	*"[difficult] getting an immediate response about the project they were working on"*
	Less opportunity for informal teaching	*"I like to have my student beside me at most times so that ... we can chat freely about my actions, thoughts …"*
Theme 2: Preparation and ongoing support are needed to ensure readiness and to manage expectations	Wanting support in teaching and precepting	*"There needed to be guidelines about what a successful rotation looked like & how to deal with struggling students…"*
	Appropriate scope of work and workload	*"Better guidance on how to assign proper workload to the student… it would be nice to have some guidance to help ensure the work assigned is fair to the student"*
	Student and preceptor preparedness	*"Preparation is key. I spent more time than usual preparing, including copying textbook chapters that the student would not have access to, ordering a textbook to be delivered to student's address…"*
		"Need to make a community of practice for students and streamline types of presentations to help them have peer support."
Theme 3: Recipe for Success – Pedagogy, technology, and a dose of motivation	Adopting new pedagogy	*"It's hard at the beginning but we adapted and came up with better working solutions that we will be able to apply to future NDPC rotations."*
	Need access to reliable technology	*"Ensuring your students have the right technology before the rotation begins…One of my biggest challenges have been getting the students access to confidential information."*
	Motivation to precept	*"…I love to teach--this is an important part of my career"*

Discussion

When the pandemic interrupted experiential education, the Leslie Dan Faculty of Pharmacy, University of Toronto PharmD programme switched to fully remote rotations to ensure that students could safely continue to learn and progress toward graduation on time. This study explored early experiences with precepting NDPC remote rotations. The survey respondents were primarily experienced preceptors, which is advantageous as these individuals would have a solid understanding of what it means to provide an in-person experiential rotation as a comparator to their remote precepting experience. The authors identified three major themes centred on the preceptor-student relationship, preparation and ongoing support, and considerations for a successful remote experience. Overall, preceptors reported satisfaction in leading a remote rotation.

While most preceptors employed video communication and agreed that remote meetings with students were productive, half found developing relationships more difficult. This finding is significant as this study further demonstrates that the top motivators for preceptors included establishing good rapport and building student engagement. Similarly, as experienced in nursing preceptorship, Rand & Pajarillo (2015) noted that the development of social and professional connections is critical for successful precepting and mentoring. Similarly, various strategies related to enhancing teaching and relationship building in remote learning have recently been suggested in the pharmacy education context. Hundal and colleagues (2021) invited students to virtual orientations, conducted daily check-ins and connected with students to gain feedback on progress and concerns during the rotation to develop student engagement and motivation. From a student's perspective, Zhu & Brown (2021) demonstrated that students stayed motivated during rotations when they built a positive rapport with preceptors, and therefore, resources should be created to enable preceptors to achieve this.

Preceptors expressed a loss of in-the-moment teaching opportunities and found it more difficult to track student progress and gauge student understanding. This was further underscored by these findings that two-thirds of preceptors provided formative feedback infrequently. In-person rotations provide more wholesome opportunities for informal observation of impromptu interactions and activities, especially for "*soft skills*", including non-verbal communication and professionalism (Moreau *et al.,* 2021). Other health professionals similarly identified the importance of prompt yet formal and structured feedback and assessment, noting that it is more challenging to provide this in a virtual setting than in in-person rotations (Rand & Pajarillo, 2015; Abraham *et al.,* 2020;). Abraham and colleagues suggested the use of a checklist as a standardised way of evaluating each telehealth encounter during medical students' internal medicine clerkships. While additional learning often happens organically during in-person rotations, adopting strategies for a more structured approach may be necessary to create explicit learning and assessment/feedback opportunities that are limited in remote rotations. Law and authors implemented "*virtual APPE playbooks*" that included a schedule of weekly topics and tailored mock activities that aligned with learning objectives. For instance, the hospital pharmacy playbook facilitated learning through medication reconciliation role play and virtual cleanroom simulation (Law *et al.,* 2021). Similarly, studies have recognised the need for structured learning activities. Researchers have employed activities such as clinical debates, disease state presentations, patient case discussions, and journal club presentations, which are all activities that typically occur in traditional clinical in-person rotations (Montepara *et al.,* 2021; Moreau *et al.,* 2021).

To facilitate adapting to remote rotations, preceptors identified the need for preparation and ongoing support for both themselves and students. A paucity of resources existed during the study period. Since then, there has been significant growth in the availability of guidelines and best practice resources established by faculties across health professions to better support preceptors in the virtual learning environment (Northern Ontario School of Medicine, 2020; Law *et al.,* 2021). Recognising this deficit, the authors hosted weekly online forums for preceptors. The authors focused on the adaptations required to precept in a remote environment and covered topics such as assessment and feedback, creating meaningful learning objectives, work-from-home strategies and teaching tips. The authors also hosted open forums for participants to ask questions and share lessons learned regarding precepting NDPC rotations during a pandemic. Increased workload responsibilities and scheduling conflicts hindered attendance, while almost one-third of preceptors felt they were already familiar with the topics. Although most were experienced preceptors with leading in-person rotations, there are different skill sets and considerations as to what constitutes readiness for precepting remotely. Preceptors face various challenges related to adapting to uncertain situations, transitioning from the traditional work environment, and working with a lack of standardised guidelines to integrate students into remote APPE experiences (Cooley *et al.,* 2021; Law *et al.,* 2021). In future, consideration should be given to providing more flexible options for supporting preceptors and delivering preceptor development.

The third major theme related to how pedagogy, technology, and motivation enable success in remote rotations. Preceptors reported increased reliance on technology during remote rotations and the necessity of confirming that students had access to reliable internet and devices to facilitate communication and exchange of confidential information. Likewise, this was a central finding that resonated with several studies in remote learning (Fuller *et al.,* 2020; Johnson *et al.,* 2022; Louiselle *et al.,* 2020; Northern Ontario School of Medicine, 2020). As noted by Law and authors, the pandemic has necessitated the incorporation of creative strategies and teaching tools, such as mock clinical activity sheets and guidance documents, to pivot to remote precepting (Law *et al.,* 2021).

Remote rotations sparked innovation and generated new ideas for delivering experiential education. For example, social distancing requirements and competing priorities meant fewer staff were available at sites to attend presentations. The faculty shifted towards a remote presentation model using Zoom, which allowed us to invite the entire student class, preceptors, and their staff. The shift to completing experiential rotations remotely was unexpected and can be quite isolating (Strawbridge *et al.,* 2022). Several participants suggested creating a student community of practice to foster social well-being and shared learning. Similarly, findings from a survey of students who completed remote ambulatory care and community pharmacy APPE rotations rated their online learning sessions with preceptors and students highly (Hatcher *et al.,* 2022). This format allowed them to collaborate with peers and gain a diversity of perspectives from preceptors from multiple practice sites. Collaborative learning among students from different schools of pharmacy and facilitated by preceptors in various specialities can enable an improved learning experience (Montepara *et al*., 2021)

There are some limitations to this study. With a 30% response rate, the survey participants may not be representative of the preceptor group. The authors were cognisant of limiting non-essential communication as preceptors had added responsibilities related to the pandemic whilst adjusting to an unfamiliar model of teaching. The authors felt the response was sufficient, considering it was an experienced group with prior in-person precepting as a frame of reference. The study period occurred relatively early in the pandemic while there were many unknowns and stresses on the healthcare system, and the authors felt it was imperative to gain the perspectives of preceptors who were key players needed for these students to successfully complete their curriculum. Second, these findings were derived from NDPC remote rotations. Remotely precepted DPC rotations would likely pose additional challenges that the authors did not explore but have been recently well documented in the literature both within pharmacy (Montepara *et al*., 2021, Moreau *et al.,* 2021; Kang-Birken *et al.,* 2022), medicine (Hayes *et al.,* 2020, Ho *et al.,* 2021) and nursing (Johnson *et al.,* 2022). Lastly, the authors did not follow up with preceptors longitudinally, which may have enriched these findings and built a deeper understanding of their experiences.

This study contributes to the limited but growing body of literature focused on remote NDPC precepting, particularly within the pharmacy education context. Given the continued expansion of virtually-delivered healthcare services, remote experiential rotations will continue to be offered at the faculty. These results can help contribute to success for future rotations and are applicable to other health disciplines engaging in remotely delivered rotations. The importance of adapting in-person precepting approaches to the unique remote context and supporting preceptors throughout the transition were key findings. With appropriate technology, educational approaches, and motivating factors, the authors feel remote rotations are a meaningful and viable mode of experiential learning.

Conclusion

The COVID-19 pandemic disrupted education delivery. Remote experiential education gained momentum and uptake in the current climate of healthcare education programmes. Recognising the paradigm shift to remote learning, the authors sought to understand preceptor perceptions and experiences. Preceptors reflected on the need to adapt the learning experience, highlighting that there is no 'one-size-fits-all' approach. They also articulated the need for greater preparation and ongoing support to thrive in this new teaching experience. Preceptors identified the crucial components of a successful remote rotation. Remote learning has opened doors to new opportunities and innovation.

Acknowledgements

We would like to thank the preceptors of the Leslie Dan Faculty of Pharmacy for sharing their experiences and the Office of Experiential Education at the Leslie Dan Faculty of Pharmacy for their administrative support.

Conflict of Interest

The authors have indicated that they have no conflicts of interest with regard to the content of this article.

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