

Virtual Patients: An Affordable and Sustainable Way to Teach Safe Prescribing to Enhance Clinical Competence

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ABSTRACT

Patient safety is a fundamental priority in medical practice, and safe prescribing is a critical component of preventing medication-related harm. Despite its importance, prescribing errors remain common, while medical students may have limited opportunities to develop and practise prescribing competencies in authentic clinical contexts. This is a global challenge, and Malaysia is no exception. Conventional approaches, including small-group teaching and simulation-based learning, can be resource-intensive and difficult to implement at scale. This project therefore proposes developing an artificial intelligence (AI)-powered virtual patient system as an innovative, scalable, and sustainable approach to prescribing education. Grounded in experiential learning principles and established frameworks for safe prescribing, the system will present students with authentic clinical scenarios that require prescribing decisions and provide immediate, contextualised feedback. The virtual patients will respond dynamically to students' prescribing decisions, including improving when appropriate medications are prescribed or experiencing adverse outcomes when inappropriate prescriptions are made, providing a safe environment in which students can make, recognise, and learn from errors without exposing real patients to harm. The proposed system will be integrated longitudinally into the undergraduate medical curriculum through a spiral approach, whereby students encounter foundational prescribing scenarios during the pre-clinical years and progressively revisit more complex clinical situations throughout their clinical training. Students' prescribing competence and error patterns will be assessed longitudinally to evaluate changes in performance over time. By integrating artificial intelligence with evidence-based pedagogy and experiential learning, this project aims to provide an affordable, scalable, and sustainable solution to strengthen prescribing competence and promote a culture of medication safety among future medical practitioners.

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1. INTRODUCTION

The importance of safe prescribing skills cannot be overstated, as a lack of them affects patient safety. The British Pharmacological Society (BPS) framework for prescribing skills comprises eight domains. Based on this, we define prescribing errors (PE) to include medication errors, which constitute a significant problem in healthcare globally. What makes it so devastating is that healthcare professionals have patient safety uppermost in their minds, striving to reduce morbidity and mortality. However, prescribing errors are a preventable cause of morbidity and mortality (Lloyd, 2019). Prescriptions written by final-year medical students and junior doctors indicate a critical gap in their preparedness for prescribing responsibilities (Kalfsvel et al., 2022). These inadequate skills often stem from an inability to link theoretical knowledge with clinical application. One aspect of prescribing training emphasises this link (Tobaiqyet et al., 2024; Kalfsvel et al., 2022). In addition, traditional medical education often overlooks applied pharmacology, a crucial aspect of the field.

In Malaysia, recent studies emphasise these concerns. A 2019 review at Hospital Raja Permaisuri Bainun in Ipoh identified 1,045 medication-related incidents, with the vast majority (97.5%) being near-misses and 2.5% actual errors. Crucially, 97.4% occurred during the prescribing stage, with dosing mistakes accounting for over half of cases (52.3%) and cardiovascular drugs being most frequently involved (25%) (Yatim, 2022). A study done by the Emergency Department of Hospital Universiti Sains Malaysia in Kelantan found that analgesics were the drugs most often linked to PE. Although most of these incidents did not cause harm, they do show a worrying trend of PE happening even in emergencies (Shitu, 2020). This highlights the importance of healthcare professionals improving their prescribing practices. The number of PEs in developing countries like Malaysia is about the same as in developed countries. An observational study in Selangor found that administration errors accounted for 85% of dose errors. These errors persisted even after accounting for timing errors. This research noted that mistakes are common when people prepare and administer intravenous medicines in low-resource settings (Basil, 2019).

Grasping pharmacological concepts and developing sound prescribing skills are essential in preparing future doctors to make safe, effective, and evidence-based treatment decisions. Strengthening these competencies is critical not only for reducing PEs but also for improving the overall quality and safety of patient care (Brinkman et al., 2018).

The scope of these PEs encompasses both identifying and correcting them. According to the Ministry of Health, between 2017 and 2019, pharmacists intervened in 1.8% of wrong prescriptions, mostly dealing with wrong dosages, wrong medications, and wrong frequency levels (Tan, 2024). Limited prescribing skills among healthcare professionals worsen the problem. For example, a study in the Federal Territory of Labuan found that only 35% of them could correctly answer questions about PE. Most people know mistakes can be avoided and that reporting them is important, but 40.2% of those surveyed did not report because they feared what might happen if they did. This shows how important ongoing education is for improving incident reporting and reducing its number (Zahary, 2021).

Encouragingly, a more recent study at the Machang District Health Office demonstrated a 21% reduction in PE and a 33.3% reduction in dispensing errors following targeted educational and technology-based interventions (Zahari, 2023). Collectively, these findings underscore the urgent need to strengthen practical, safe prescribing training within the Malaysian healthcare context, ultimately aiming to reduce errors and significantly improve patient outcomes.

Virtual patients represent a transformative pedagogical tool for medical education, particularly within the critical domain of safe prescribing. This approach leverages artificial intelligence to create highly interactive and adaptive learning environments that simulate complex clinical scenarios and provide immediate, personalised feedback, enabling students to practice prescribing decisions without risk to actual patients. Existing literature demonstrates that virtual patients are effective interactive digital simulations that improve various aspects of learning, including core knowledge, clinical reasoning, decision-making skills, and knowledge transfer (Li et al., 2024).

One of the main reasons the current method of prescribing training may be inadequate is that, under the traditional approach, it is less structured and requires resource-intensive methods that are highly demanding for clinicians practising in a busy hospital. A more progressive, scalable, and sustainable approach is to use technology.

The proposed project aims to develop an AI-powered virtual patient platform that is designed to teach safe prescribing. Many patient aspects, such as comorbidities and other drugs that the patient is on, as well as drug aspects, such as predictable side effects, must be considered before a correct prescription is written. Prescribing training must be done in a safe environment to build skills and address the problems junior doctors face when applying classroom learning to real-life prescribing situations. Equipping them with robust prescribing skills will ultimately enhance patient safety and boost students' confidence.

2. METHODOLOGY: A PROPOSED FRAMEWORK FOR AN AI-POWERED VIRTUAL PATIENT PLATFORM

We are proposing a new approach to enhancing safe prescribing education through an AI-powered virtual patient platform. This project will move beyond theory by integrating hands-on, experiential learning with adaptive artificial intelligence to create a powerful, scalable, and effective educational tool. The primary aim will be to improve prescribing accuracy, build students' confidence, and provide a sustainable alternative to traditional teaching methods.

The platform will use a modular structure to simulate realistic clinical scenarios. It will deliver adaptive feedback that responds to each student's decisions, bridging the often-challenging gap between theoretical learning and real-world application. The system will include core modules for scenario management, AI-driven interaction, a user-friendly interface, and structured feedback delivery. Advanced AI components, including Natural Language Processing (NLP) and Clinical Reasoning AI, will make these functions possible by allowing the system to understand student input, evaluate prescribing decisions, and generate dynamic, context-aware patient responses (Hicke et al., 2025).

Specifically, the NLP module will support natural communication during history-taking and prescribing exercises. At the same time, the Clinical Reasoning AI will assess each decision against established clinical guidelines and patient safety standards. Additionally, large language models will be explored for their potential to evaluate drug selection, dosage accuracy, and potential drug interactions (Luo et al., 2025).

2.1 Experiential Learning in Practice

To strengthen experiential learning, a comprehensive case library will be developed. These will not be mere theoretical exercises but diverse and realistic clinical scenarios, such as hypertension and hypertensive emergencies. Each case will encourage students to think critically and make clinical decisions in a safe, interactive environment where mistakes are treated as learning opportunities rather than failures. Through a user-friendly interface, students will actively engage and immerse themselves in managing virtual patients, applying their pharmacological knowledge in authentic clinical contexts (Sun et al., 2024).

2.2 Debriefing and Reflection: Learning from Every Scenario

After each scenario, students will receive immediate, structured reports generated through integrated debriefing and reflection tools. These reports will not only highlight correct decisions but will also show response times and key reasoning steps. This process will encourage students to reflect critically on their performance and self-assess through guided questions on diagnosis, drug selection, and patient communication. They will also be able to compare their decisions with expert recommendations based on current clinical guidelines (Fink et al., 2021; Liu et al., 2021). This structured reflection will turn every simulation into a meaningful learning experience, gradually building students' prescribing confidence and competence (Hicke et al., 2025).

2.3 Clinical Case: Hypertension with a Prescribing Error (Propranolol in a Patient with Asthma)

To illustrate our vision for the platform's educational design and practical application, we created a sample clinical scenario focused on managing hypertension. This case highlights a common PE, which is prescribing propranolol to a patient with asthma. This example shows how the system promotes experiential learning, clinical reasoning, and safe prescribing through adaptive feedback and structured reflection (Hicke et al., 2025).

Scene 1: The Consult

The setting will take place in a virtual medical outpatient clinic where the student, acting as the prescribing doctor, will interact with a 48-year-old male patient, newly diagnosed with hypertension. The learning objective will be to obtain a thorough medical history, perform a focused clinical assessment, and prescribe an appropriate antihypertensive medication safely and effectively. The interactive format will allow students to communicate naturally with the patient, simulating an authentic consultation experience in a controlled, risk-free environment.

Scene 2: History Taking

Students will interact with the patient avatar, either through text or voice prompts, to gather essential patient history, including comorbidities that influence prescribing decisions. This scene will unfold in two possible ways:

- Outcome 1: Comprehensive History

The student will take a complete medical history, identifying the patient's asthma, which is well-controlled with regular use of Seretide (a combination of salmeterol and a corticosteroid).

Gamification: The student will earn points and receive a "Safe Prescriber" badge for obtaining crucial information through effective history-taking.

- Outcome 2: Incomplete History

The student will fail to obtain a thorough history, overlooking the patient's asthma and regular inhaler use. This incomplete history will result in a lower performance score.

Gamification: The system will issue a penalty, provide immediate feedback, and record this as a "critical error," indicating that essential patient information was missed.

Scene 3: Prescribing Decisions

The prescribing interface will present antihypertensive options, and the student's selection will lead to one of the following outcomes, reinforcing evidence-based decision-making and patient safety:

- Outcome 1: Correct Prescribing Based on Clinical Reasoning

The student will correctly recognise that propranolol is contraindicated in asthma and will select an appropriate alternative, such as amlodipine.

Gamification: Additional points and a "Safe Prescriber" badge will be awarded.

- Outcome 2: Incorrect Prescribing Due to Knowledge Gap

The student will identify the asthma history but still choose propranolol, reflecting limited understanding of drug-disease contraindications and drug-drug interactions.

Gamification: The system will issue a penalty, trigger feedback, and record a “critical error,” highlighting the knowledge gap.

- Outcome 3: Incorrect Prescribing with Delayed Consequences

The student will prescribe propranolol incorrectly, but feedback will be intentionally delayed. In a follow-up simulation, the virtual patient will return with an acute asthma exacerbation. This delayed feedback will prompt critical reflection on the impact of the initial prescribing decision.

Scene 4: Consequence Simulation

If the system is set not to provide immediate feedback, the virtual patient will return after one week of propranolol therapy, presenting with symptoms of an asthma exacerbation such as coughing, wheezing, and increased reliance on a rescue inhaler. The student will be prompted to reassess the case, recognise the PE, and choose a safer alternative. The feedback module will explain that propranolol blocks β_2 receptors, leading to bronchoconstriction, and guide the student to correct the mistake. This process will reinforce clinical reasoning, reflective practice, and the ability to learn from errors within a safe, supportive learning environment.

2.4 Gamification and Reflection Features

Gamification features will be added throughout the simulation to keep students engaged and to support their learning (Lee et al., 2025). In the proposed case, students will earn points and badges for correct prescribing and for following safety procedures. They will also receive clear visual feedback and performance updates. For example, safe prescribing will earn a “Safe Prescriber” badge, while unsafe decisions will trigger warning messages or penalty icons, encouraging students to try again and improve. These game-based features will help students stay motivated, practice with purpose, and receive timely feedback.

In some cases, feedback will be given later so that students can see or understand the possible negative effects of their prescribing choices. Challenge scenarios will also be included to test how students make decisions under pressure, helping them build confidence and resilience when managing complex cases. A performance dashboard will allow students to track their progress, see their achievements, and identify areas that need more practice (Alsadoon et al., 2022).

Alongside the game elements, reflection and debriefing tools will be equally important. The replay feature will let students review completed cases and think carefully about the reasoning behind their choices. Together, these elements, which include timely feedback, progress tracking, and repeated practice, will motivate students, strengthen their understanding of pharmacology, and steadily improve their prescribing accuracy.

2.5 Educational Impact

The AI-powered virtual simulations will combine adaptive feedback, hands-on learning, and game-like features to support safe and effective prescribing behaviour. By linking pharmacology theory with real-life practice, students will develop critical thinking and clinical reasoning skills in a supportive, risk-free environment. Through repeated practice and reflection, they will gain confidence and competence in making evidence-based prescribing decisions. In the long term, this approach will help students develop responsible prescribing habits, increase their awareness of patient safety, and prepare them to deliver safe, effective, and patient-centred care.

2.6 Evaluation of Engagement

Student engagement will be a key measure of the platform's effectiveness as a learning tool. The number of students who return to use it regularly will show how interested and motivated they are to learn. The evaluation will also look at how the platform's game-like elements, instant feedback, and adaptive learning features affect motivation, participation, and knowledge retention.

Quantitative data, such as the number of logins and completed activities, will be supported by qualitative feedback about students' experiences, including what they find most helpful and their satisfaction level. Students will also be encouraged to share open comments about which parts of the platform, such as interactivity, challenge level, or game features, help them learn best, as well as areas they find less engaging.

This feedback will guide continuous improvements, making the platform more engaging, effective, and meaningful for future learners.

2.7 Scalability and Sustainability

Scalability and sustainability will be key considerations in the platform's design and implementation. The system will use a modular, reusable structure, allowing new cases, learning materials, and features to be added without major redevelopment. This approach will ensure the platform can evolve with curricular changes and technological advancements (Hicke et al., 2025). Automation will form the core of the system's methodology, with AI managing interaction, evaluation, and feedback. This will reduce dependence on continuous faculty supervision while maintaining consistent quality in assessment and feedback delivery.

The case library and simulation logic will be designed to support reusable and adaptable content, minimising the need for frequent manual updates (Luo et al., 2025). Automated debriefing tools will also be embedded to promote reflective learning while improving instructional efficiency (Liu et al., 2021). Together, these design strategies will ensure that the system is sustainable, scalable, and adaptable across different medical institutions and class sizes, offering a practical and lasting solution for safe prescribing education. The modular design will ensure long-term adaptability, supporting independent development and system expansion as technology and curricula evolve.

3. EXPECTED OUTCOMES AND BENEFITS

The proposed AI-powered virtual patient platform is expected to deliver several key benefits, primarily by improving education and training in safe prescribing. It aims to increase prescribing accuracy, strengthen student confidence, and provide a scalable, sustainable educational model. Overall, the system will help transform medical training by preparing future healthcare professionals with the knowledge, confidence, and skills needed for real-world prescribing practice (Hicke et al., 2025).

3.1 Improved Prescribing Accuracy

The platform is designed to improve prescribing accuracy by tackling the ongoing challenge of applying theoretical pharmacology in real clinical settings. Using realistic patient scenarios and instant, personalised feedback, students will have repeated chances to practise prescribing safely. This hands-on learning process, supported by adaptive AI, will help them understand correct prescribing principles, recognise the effects of their choices, and reduce common prescribing errors such as incorrect dosing. Through practice and reflection, students will become better able to manage the complex and unpredictable nature of real patient care (Fink et al., 2021).

3.2 Increased Student Confidence

The platform will help students build confidence by providing a safe space to make mistakes and learn from them without risking patient safety. Game-like features will make learning more engaging and enjoyable, encouraging students to stay motivated throughout their training. With ongoing practice, clear feedback, and progress tracking, students will gradually strengthen their clinical judgement and prescribing skills. As their confidence grows, they will find it easier to move from classroom-based learning to real patient care. This supportive, interactive approach will help them develop the competence and self-assurance needed to make safe, effective prescribing decisions (Alrashidi, 2023).

3.3 Scalable and Sustainable Education

The platform will also provide a flexible and lasting model for medical education. By using AI to manage patient interactions, performance assessments, and feedback, it will make high-quality training consistently accessible to large groups of students. This approach will help address common challenges in traditional teaching, such as heavy staff workloads and limited access to simulation resources. The platform's modular design will make it easy to update and expand as technology and medical curricula evolve, ensuring its long-term value. Its scalability will allow medical schools across regions to adopt a shared, effective approach to prescribing education, helping prepare a new generation of skilled, safety-focused healthcare professionals (Hicke et al., 2025).

4. DISCUSSION AND CONCLUSION

Prescribing errors remain an important and preventable cause of patient harm, with junior doctors contributing substantially to such errors (Ross et al., 2009a). Evidence also suggests that many medical students graduate with insufficient preparedness, confidence, knowledge, and skills to prescribe safely and effectively (Brinkman et al., 2018). These findings highlight the challenges of translating knowledge of clinical pharmacology and therapeutics into competent prescribing practice and underscore the need for undergraduate medical education to provide effective opportunities to develop and apply prescribing skills (Brinkman et al., 2018; Ross et al., 2009b).

Although traditional approaches such as tutorials, case-based learning, and simulation can be effective in developing prescribing competencies, opportunities for structured and hands-on prescribing practice during undergraduate medical training may be limited. Malaysian evidence suggests that prescribing training has not always been systematically integrated into undergraduate curricula, with students sometimes acquiring prescribing skills in an ad hoc manner during clinical placements (Lai et al., 2015). This is important because inadequate prescribing training may contribute to insufficient preparedness for safe prescribing. At the same time, approaches that connect pharmacological knowledge with authentic clinical scenarios can help bridge the gap between theory and practice (Hasamnis et al., 2019). These challenges highlight the need for accessible, sustainable, and clinically relevant educational approaches that give students repeated opportunities to develop safe, confident prescribing skills.

This proposed project aims to meet that need by developing an AI-powered virtual patient platform that supports safe prescribing education. The platform will give students an interactive, flexible space to practice prescribing in realistic clinical situations without risk to real patients. Its modular design will include cases of different difficulty levels, suitable for various stages of medical training. Real-time, personalised feedback will help students understand the impact of their choices and improve their clinical judgment. By practising with a wide range of cases, students will strengthen their knowledge of pharmacotherapy and develop a deeper appreciation of patient safety (Arfiyanti et al., 2021; Hicke et al., 2025).

Using adaptive AI, the platform will respond dynamically to students' prescribing decisions, illustrating how a patient's condition may change immediately or over time. By providing interactive feedback on clinical decisions, the platform is intended to encourage reflection, enable students to learn from errors, and support the development of safer prescribing practices. Virtual patient approaches have shown potential to improve clinical reasoning, particularly in areas such as data gathering, diagnosis, and patient management (Plackett et al., 2022), while emerging evidence suggests that AI-enhanced virtual patients may further support clinical reasoning through adaptive interactions and feedback (Mofidi & Khoshgoftar, 2026). By simulating the complexity of clinical decision-making in a controlled learning environment, the proposed platform aims to help students integrate pharmacological knowledge with clinical reasoning and develop greater confidence in prescribing decisions.

Game-like features such as points, badges, and challenges will make learning more engaging and rewarding. At the same time, automated debriefing and reflection tools will help students review their decisions, think critically, and identify areas for improvement. This AI-driven approach provides a practical, scalable, and sustainable way to enhance medical education. It tackles the challenges of traditional teaching by reducing dependence on staff-intensive methods and offering consistent, high-quality learning experiences for large groups of students. Its modular design means it can easily be updated and expanded, ensuring it remains useful as technology and curricula evolve. Because it can be adapted across institutions and regions, it has the potential to bring standardised, high-quality prescribing education to medical schools worldwide (Hicke et al., 2025).

By working with AI-powered virtual patients, students will not only strengthen their decision-making skills but also learn to recognise and manage side effects and drug interactions more effectively (Duffull & Peterson, 2020). The platform will encourage self-directed learning, thoughtful reflection, and careful clinical reasoning, helping future doctors to prescribe with both skill and confidence.

Ultimately, this project represents more than just a technological innovation; it is a step towards more compassionate, effective, and safer healthcare. By bringing together advanced technology and good teaching practice, it offers an affordable and sustainable way to help students grow into confident, competent, and empathetic doctors. In doing so, it supports a future where safe prescribing is not just taught but truly understood and lived in everyday medical practice.

5. LIMITATIONS OF THE PROPOSED PROJECT

Although the expected benefits of this project are considerable, it is important to recognise the potential limitations of using advanced educational tools. It is equally important to consider practical ways to address these challenges and make the most of the project's opportunities.

5.1 Nuances in Clinical Reasoning

While AI can generate knowledge and recognise patterns effectively, purely algorithmic systems may still struggle with complex, uncertain situations that require human intuition and deeper understanding. This limitation highlights the need to improve AI design by involving human expertise and real-world context. The project will address this by refining AI models with varied, complex datasets and including human review at key stages to capture subtle aspects of clinical reasoning.

5.2 High Development and Maintenance Demands

Building and managing an advanced AI-powered virtual patient platform will require significant initial investment and ongoing maintenance to keep it up to date and clinically relevant. These practical challenges highlight the importance of sustainable, shared approaches that balance innovation with efficient resource use. The project will aim to build partnerships and use open-source AI tools to share costs, encourage collaboration, and speed up the platform's development.

5.3 Potential for Over-reliance on the Simulated Environment

Students may become too dependent on the structured and predictable nature of simulated learning, which could make it harder for them to adapt to real clinical settings that are often more uncertain and less controlled. Recognising this risk will guide the project to design learning activities that gradually include more complex and less predictable situations. This will be achieved by introducing scenarios with increasing levels of uncertainty and delayed feedback, helping students prepare more effectively for real clinical practice.

5.4 Bias and Generalisability in AI Algorithms

AI models trained on limited or unbalanced data may carry or increase existing biases, which could affect performance across different patient groups. This limitation highlights the need for fair, transparent AI systems that can be applied across a wide range of clinical situations. The project will address this by using data from several institutions and applying explainable AI methods to identify and reduce bias, helping ensure fair and reliable learning across all patient cases.

6. CO-AUTHOR CONTRIBUTIONS

The authors declare no conflict of interest regarding this article. Nafeeza Mohd Ismail developed the main project idea, prepared the literature review, and oversaw the overall write-up of the whole article. Sunil P. Venkateswaran created the clinical scenarios and contributed to the design of the proposed methodology. Aida Lina Alias developed and evaluated the existing virtual patient platform used in this project.

Nafeeza Mohd Ismail: Conceptualisation, literature review, project administration, supervision, and writing – original draft; Sunil P. Venkateswaran: Conceptualisation, methodology, development of clinical scenarios, and writing – review and editing; Aida Lina Alias: Software, methodology, validation, and evaluation of the existing virtual patient platform, and writing – review and editing.

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9. AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the concept and design of the virtual patients and manuscript preparation.

10. CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this work.

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