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Development, Testing, and International Uptake of a 'Just-in-Time' Clinical Skills Training Application for Medical Student Education

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ABSTRACT

Medical student education may incorporate adjunctive teaching methods to enhance procedural skill competencies. A 'Just-in-Time Training' (JITT) smartphone application (app) was developed in New Zealand to enhance the undergraduate clinical skills teaching programme. The Clinical Skills app was developed at the University of Otago Christchurch Simulation Centre. Content was based on the taught undergraduate programme and includes checklists and photo/video guides for 19 clinical procedures. Usability has been assessed annually using the System Usability Scale (SUS) since 2022, and mean scores > 73/100 represent good usability. The app has been open source since 2017 for iPhone Operating System (iOS) and 2019 for Android users. Cumulative downloads and daily user numbers are recorded. The SUS was completed by 251 medical students over three years; the mean score increased from 74/100 in 2022 to 87/100 in 2024 ($p < 0.001$). The cumulative international downloads between 2017–2024 were 706,607. In 2023, there were 7,437 international downloads, increasing by 104% to 15,193 users in July 2024, with users located in 155 countries, mainly New Zealand (22%), and China (18%). The increasing downloads of the JITT Clinical Skills app suggest that it is a popular learning tool to supplement clinical skills teaching.

Keywords: *Medical education, Mobile apps, Clinical skills, User experience, Uptake*

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INTRODUCTION

Medical student education has metamorphosed over the years. While the same core principles are delivered through didactic teaching, adjunctive educational methods are increasingly utilised. The acquisition of broad procedural competencies is a fundamental goal of medical education (1), but barriers to students developing competence include insufficient opportunities to practise, with opportunities being lost because students may be expected to repeatedly observe procedures before performing the task themselves (2–5). In order to address these barriers, a number of methods have been tested, including

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simulation-based education. The use of simulation-based resources has been reported as effective, leading to improved student knowledge, competency, and confidence (6–8), and is reported by students as an enabling factor in overcoming learning barriers (2). Short instructional videos have been shown to be effective at improving specific skills (9), and clinical skills training videos via online platforms, such as YouTube, have been shown to have high uptake (4). In addition, the use of 'Just-in-Time Training' (JITT) interventions has been implemented, with JITT referring to training that takes place in the clinical setting when a learner needs to perform a procedure but lacks proficiency, confidence, or wishes to refresh their knowledge (10). In the clinical setting, time and space are often limited, and JITT provides the opportunity to review critical steps of procedures prior to practise, strengthens mental focus, and allows educators to reinforce the micro-skills necessary for successfully performing procedures (10). The JITT model has been around for many years and has been adapted for use in the clinical setting in response to the increasing complexity of patient care and the volume of knowledge required to navigate clinical learning and decision-making (11,12). In recent years, JITT interventions, in the form of smartphone/mobile apps, have proven effective at improving clinical skills (13–16). The most effective approach to medical student training, overcoming the known barriers to learning and retaining practical clinical skills, is to develop interventions that address all approaches to maximise student engagement and outcomes.

In New Zealand, the University of Otago Christchurch Medical School has developed a Simulation (SIM) Centre to expand its clinical skills programmes and deliver simulation-based education covering a broad range of clinical and professional skills (17). In order to supplement the undergraduate didactic clinical skills teaching and simulated procedural education, a JITT clinical skills mobile app called 'Clinical Skills' (18,19) was also developed to provide students with a real-time resource they could access in any environment, with the aim that development would be iterative and respond to student feedback at the end of each year placement. The pedagogical approach to incorporating the Clinical Skills app into the established teaching structure was through blended learning, which combines classroom teaching with mobile technology to create an effective, multifaceted learning environment that helps bridge the gap between theory and practice (20,21). Blended learning provides a flexible and reflective approach that addresses some shortcomings of face-to-face teaching found when teaching medical students clinical skills competencies, such as time, experience, patient access, and resources (22,23). This method of education has been successfully used in student teaching across learning environments, with empirical studies reporting improvements in self-directed learning, skill competencies, self-efficacy, and clinical reasoning (22–25). In addition, blended learning has been shown to improve student course satisfaction, engagement, motivation, and social presence, while underscoring the ongoing need for face-to-face instruction and guidance, with interventions such as mobile apps playing an important adjunctive role (22,23,25,26). The Clinical Skills mobile app development process is described herein, with student feedback outlined and international reach established.

METHODS

For the purpose of designing, developing and testing the usability of the Clinical Skills app, the principles of the International Organisation Standard for Human-centred design for interactive systems [Part 9241–210] (27) were followed (Figure 1). This approach aims to make systems useful as well as usable by ensuring that system development focuses on end users, their needs and requirements, thereby enhancing effectiveness and efficiency, user satisfaction, accessibility, and sustainability (27).

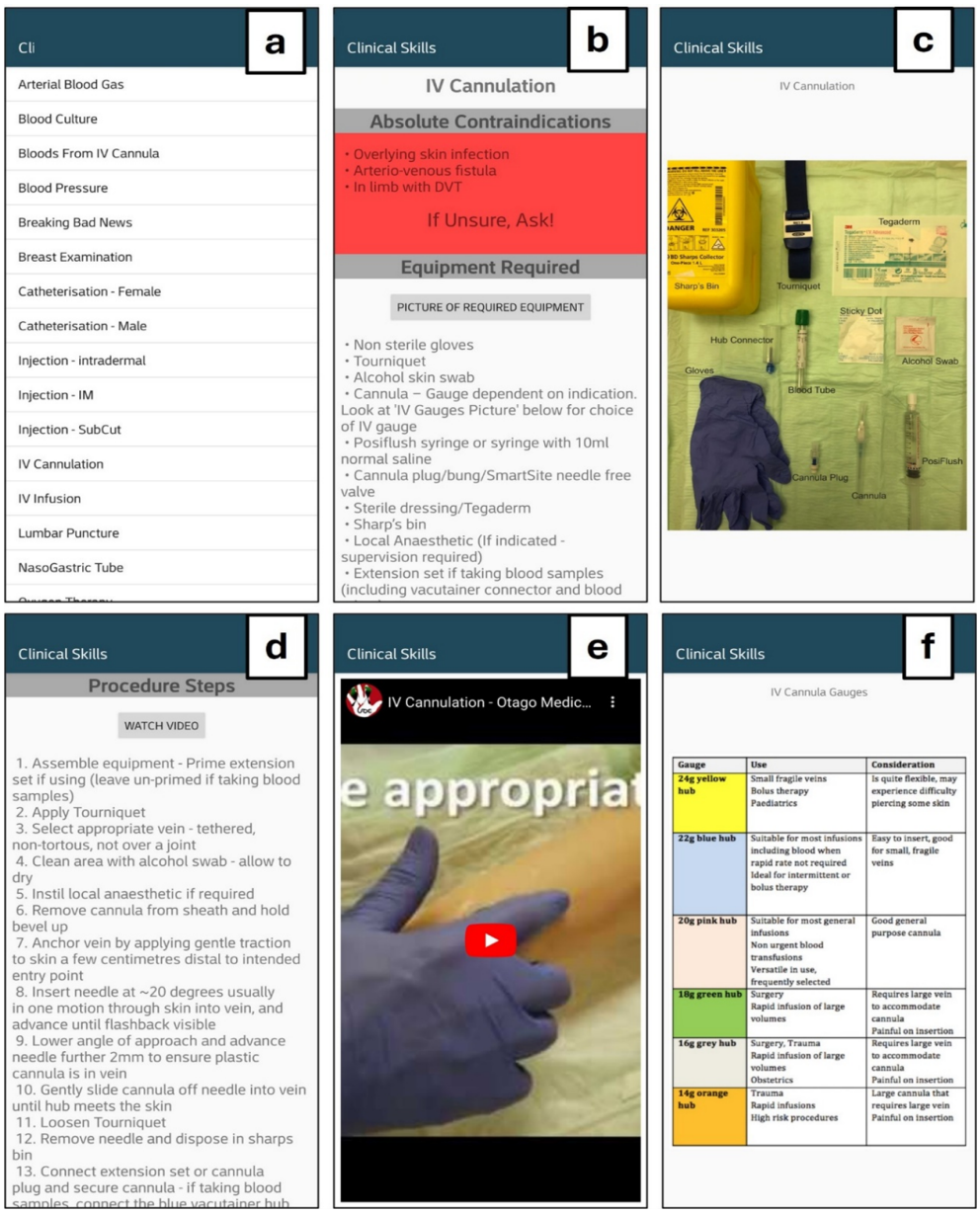

Figure 1. Diagrams of app content, starting with the main list and the procedure for intravenous (IV) cannulation, selected to show the flow through the app.

Note: (a) main list; (b) IV cannulation list of equipment; (c) picture of equipment; (d) procedure steps; (e) video of procedure; (f) = specific information.

Understand and Specify the Context of Use

The Clinical Skills app was developed in response to a need identified by SIM Centre leaders for an adjunctive resource to facilitate the transition from undergraduate to postgraduate clinical learning among University of Otago medical students. While simulated teaching could deliver and support students' learning of clinical skills in a controlled environment, in-person bedside teaching immediately before students performed procedures, both during index events and repetitions, was not possible or feasible. As such, it was determined that a smartphone app could act as an 'outreach' teaching resource, accompanying students into clinical areas and utilised immediately before preparing and performing procedures, as well as in non-clinical areas to enhance revision of clinical skills.

Specify the User Requirements

It was essential that the app's content matched the University of Otago clinical skills curriculum for 4th-year medical students. As such, the taught clinical skills were listed and each task broken down into components that could be presented in an organised and logical format. During clinical skills teaching at the SIM Centre, medical students were taught procedures that included: equipment required to carry out the procedure, contraindications for performing the task, specific information needed (examples: examination pattern for breast examination, intravenous (IV) cannula gauges, lumbar puncture position, female/male anatomy for catheterisation) and then steps to carry out the procedure. The app needed to deliver these requirements in a written format as well as including audiovisual components where possible/feasible.

Produce Design Solutions to Meet User Requirements

Development

App development began in 2017 and has progressed through iterative feedback from students and resource availability for app changes, video, and content development (Table 1).

Table 1: Timeline of app development from initiation to current day

Year	Version	Additions/changes
2017	1.0	App developed and available on iOS devices 17 procedures added at start
	1.1	Text and layout formatting
2018	Android version released and mirrors changes in iOS version	
	1.2	Photos available on Android devices as on iOS. Feedback first collected in October
2019	1.3	Updated: IV cannulation photo/procedure to match teaching hospital criteria
		Cosmetic changes
		Changed the feedback format to 'shake and send'
	2.0	New videos: IV cannulation, ABG, Venepuncture, Blood pressure, Blood cultures
		Pictures added for every item in the 'Equipment Required' (only feature not available on Android version)
2020	2.1.1	New procedure with video: PPE application
		New video: Airway, in oxygen therapy section
	2.1.2	New video: Male catheterisation
2021	2.1.3	Text formatting
	2.1.4	New video: Female catheterisation
		Updated: order of PPE to match new teaching hospital criteria
2022	2.1.5	New PPE video to replace the old one
		Removed 'shake and send' feedback
2023	2.1.6	New video: Taking blood tests from an IV cannula
		New video: Gravity fed IV fluid set-up [under IV Infusions procedure]
2024	2.1.8	New videos: Intramuscular injection, Subcutaneous injection, Intradermal injection

Note: IV = intravenous; ABG = arterial blood gas; PPE = personal protective equipment

For the iPhone operating system (iOS), the Clinical Skills app was developed in Swift using Xcode (28), Apple's integrated development environment. Although it was initially written in Swift 3, the version described in this publication complies with Swift 5, which was released in 2019. The iOS version of the app has been available in the App Store since 2017 (19). Following positive feedback from end users and requests from medical students using Android devices, an Android version of the application was developed. The Android version was written in Java using Android Studio and followed a development process similar to that of the iOS version. It has been available on the Google Play Store since mid-2019 (18).

Content

Each clinical skill was developed to have an individual site in the app, accessed via a main list (Figure 1a), and for each skill the following were included:

a. A list of absolute contraindications for performing the task (Figure 1b)
b. A written checklist of equipment required (Figure 1b)
c. A picture of the equipment required (Figure 1c)
d. A written list of procedure steps (Figure 1d)
e. A video of the procedure being performed (available for 9/19 skills, 47%), accessed via a dedicated YouTube site for the app on the relevant app procedure page (Figure 1e)
f. Where required, pictures of specific information needed for the procedure. Examples – examination pattern for breast exam, IV cannula gauges, lumbar puncture position, female/male anatomy for catheterisation (Figure 1f)

New procedures have been added as requested in student feedback, with development dependent on available resources regarding the time required for completion. As of 2025, there are 19 procedures available (Table 2).

Table 2: Procedures included in the Clinical Skills app as of July 2025, and content for each procedure

	Contraindications	Equipment list	Equipment photos	Procedure step list	Video	Additional information
Arterial blood gas	✓	✓	✓	✓	✓	Photo: Position for ABG
Blood culture	✓	✓	✓	✓	✓	Photo: Blood culture bottles
Bloods from IV cannula	✓	✓	✓	✓	✓	List: Order of draw
Blood pressure	✓	✓	✓	✓	✓	Photo: Measuring cuff size
Breaking bad news	✓	✓	✓	✓	×	Text: Empathic phrases
Breast examination	✓	✓	✓	✓	×	Diagram: Examination pattern
Catheterisation – female	✓	✓	✓	✓	✓	Diagram: Female anatomy

(*continued on next page*)

Table 2. (*continued*)

	Contraindications	Equipment list	Equipment photos	Procedure step list	Video	Additional information
Catheterisation – male	✓	✓	✓	✓	✓	Photo: Male anatomy model
Injection – intradermal	✓	✓	✓	✓	✓	Diagram: Injection technique
Injection – intramuscular	✓	✓	✓	✓	✓	Diagram: Sites for injection
Injection – subcutaneous	✓	✓	✓	✓	✓	Diagram: Sites for injection
Intravenous cannulation	✓	✓	✓	✓	✓	Table: IV cannula gauges
Intravenous infusion	✓	✓	✓	✓	✓	Table: Infusion rates
Lumbar puncture	✓	✓	✓	✓	×	Diagram: Position for lumbar puncture
Nasogastric tube	✓	✓	✓	✓	×	Photo: Measuring nasogastric tube
Oxygen therapy	✓	✓	✓	✓	✓	Table: Flow rates
PPE application	✓	✓	✓	✓	✓	Diagram: Hand hygiene
Rectal and prostate exam	✓	✓	✓	✓	×	Photo: Anatomy of examination
Venepuncture	✓	✓	✓	✓	✓	List: Order of draw

Evaluate the Design Against Requirements

Beta-testing

The app developer initially deployed the Clinical Skills app to their own personal device to assess functionality before implementing the Apple-built TestFlight Software (29). Following this basic testing, a small cohort of trainee interns and external medical practitioners was asked to test the app's functionality and provide informal feedback on the user experience.

Student feedback

Since 2018, all medical students at the end of their 4th year of clinical training at Otago University Christchurch (≈100/year) have been asked to provide anonymous feedback on their general training and SIM Centre experience as part of their end-of-year course review. This anonymous feedback includes a section asking for their review of the Clinical Skills app. Providing feedback on the app was not compulsory, and from 2018 it was collected initially in free text on paper, with no structured method for collecting this data. In 2023, feedback was still free-text but collected electronically. In 2024, a structured feedback form was developed based on previous years, with sections of the app for students to select using tick boxes to report which sections they used most and found helpful, and the aspects of the app they liked the most. In 2018, a 'Shake and Send' feature was added that enabled users to provide feedback on app issues directly to the developer by shaking their device, adding details, and sending. This feature was used by fewer than five users overall during its implementation, so it was removed in 2022, and a contact email was provided instead.

The responses to the surveys included in this study were collected as part of routine medical student training, with each student providing feedback only once, at the end of their fourth year of training.

Feedback data

The student feedback collected between 2018 and 2024 asked students to report:

a. Whether they downloaded and used the app
b. Where they used the app
c. What aspects of the app they liked and found most helpful
d. What improvements they would like to see
e. What additional procedures they would like to have in the app

Feedback analysis

Free text feedback was analysed using manifest content analysis, focusing on the visible/countable components of text to explore the use and frequency of words, categories, or themes, and not to infer meaning from the feedback (30–32). The process of manifest content analysis involves repeatedly reading free-text feedback and implementing a systematic coding and categorising approach to explore the text, identify trends, and examine word frequency and patterns (33). This coding data is then categorised into meaningful groupings using a block-and-file approach, assigning codes to topic-specific subcategories, and then into overarching categories (34).

All free-text feedback from each year group was aggregated into one document and read by three researchers (AVR, JW, NN). Identical words appearing in the text were colour-coded by one researcher (AVR), then underwent initial review to identify patterns and ensure consistent context, with colour-coding expanded if one word was used for more than one concept (for example, the use of word 'video' being colour-coded differently if referring to the benefits of silent videos, video quality, or video speed change). Words with the same contextual meaning were grouped into themes, which were then reviewed by three researchers (AVR, JW, NN) and discussed until agreement was reached. Themes were then grouped into major categories (user experience, content, features) to report aggregated results similar to those agreed upon by three researchers (AVR, JW, NN). Inter-rater reliability was not assessed because the chosen method was single coding followed by iterative discussion rounds.

Usability testing

Since 2022, the System Usability Scale (SUS) (35) has also been implemented to provide more formal feedback using a validated tool. The SUS consists of 10 items, five positively worded and five negatively worded, which respondents rate on a 5-point Likert scale (36).

Usability analysis

SUS scores are calculated by subtracting one point from the selected Likert rating value for all positively worded items, and for negatively worded items the Likert rating value is subtracted from five (36). The sum of all 10 values is then multiplied by 2.5, yielding a final SUS score up to 100, and the average is taken across all respondents if the SUS is implemented within a cohort (36). SUS scores are interpreted as follows: 0–24 = Worst imaginable, 25–38 = Poor, 49–52 = OK, 53–73 = Good, 74–85 = Excellent, 86–100 = Best imaginable (36).

RESULTS

Student Use

Since 2018, the number of students downloading the Clinical Skills app and using it at the SIM centre and on the wards has increased each year. In 2018, 41/96 (43%) of the cohort downloaded the app, increasing over subsequent years [2019: 81/96 (84%), 2020: 90/99 (91%), 2021: 92/99 (93%), 2022: 94/100 (94%), 2023: 104/113 (92%)] to a maximum number of 94/98 (98%) in 2024. The app was used on the wards by 20% in 2018 and at the SIM centre by 15%, increasing to 87% and 62%, respectively, in 2024. The number of students who did not use the app after downloading it decreased from 23% in 2018 to 1% in 2024.

Student feedback – app likes and benefits

Analysis of the free text feedback between 2018-2024 reported which parts of the app the students liked the most, and got most benefit from (Figure 2), with usability and user experience frequently appreciated, as well as the range of content and specific features such as having silent videos for discreet revision on the wards.

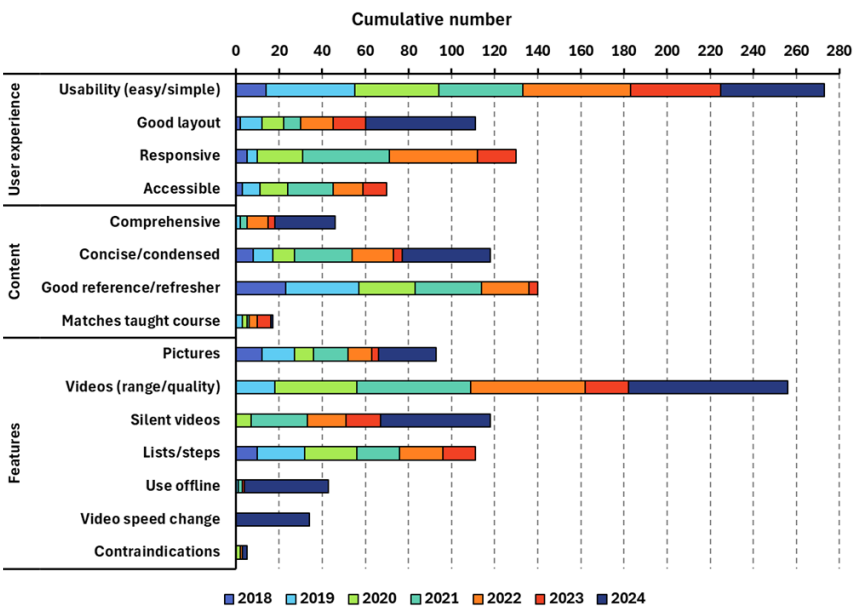

Figure 2: Analysis of free-text feedback on what students liked the most and found most beneficial.

A small number of students across the seven years provided feedback on why they did not use the app after downloading it. An issue with videos not playing on Android phones was mentioned specifically in one year, which enabled this problem to be fixed. Six students overall stated that they did not need to use the app, as their supervising clinical team were on hand to provide the information, and two preferred using either Google or a textbook to find information. Three students did not think the app would be useful. Finally, five students reported that they did not feel comfortable, or think it was appropriate or feasible, using the app on the wards. Feasibility issues were stated as: one student not having access to their phone on the wards; one said they were often put on the spot on the wards and thought it tricky to say they were going to look something up; and one said they could not read the information in time.

Student feedback – app improvements

Free-text feedback was also collected on improvements students thought could be made to the app, with the majority, over the years, requesting more videos, procedures, and pictures. While silent videos have consistently been among the most liked aspects of the app, when structured feedback was introduced in 2024, approximately 20 students requested that sound be added to the videos, as well as more diagrams and pictures than in previous years.

Student feedback – new procedures

All students had the opportunity to request specific videos or procedures to be added to the app, whether to enhance existing lists/pictures to complete the set for one skill or as new additions. This feedback was used to plan iterative stages of app development.

System usability scale

The annual mean SUS score for students using the app (excluding those that did not use it) increased each year between 2022 and 2024 ($p = 0.001$) (Figure 3). The number of students rating the app with a score deemed 'excellent' to 'best imaginable' (score ≥ 74) increased from 69% in 2022 to 88% in 2024 (X^2 9.5, $p = 0.009$). Reasons given for low scores all related to difficulties with video links not working on Android devices. This feedback enabled this problem to be remedied.

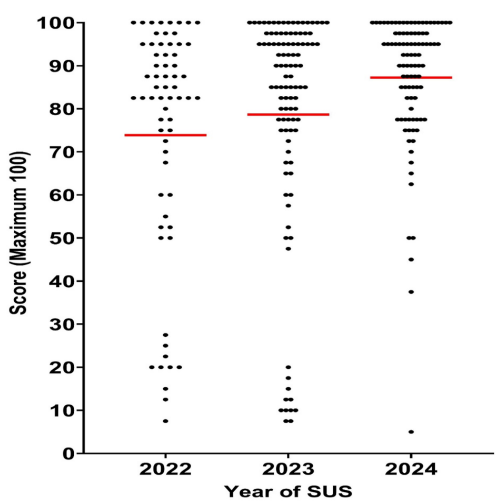

Figure 3. System usability scale score average and score distribution for annual cohorts [2022–2024].

Note: Red line denotes mean score from each cohort; SUS = system usability scale

Design Solution Meets Requirements

Downloads – New Zealand

The app developer collects data on downloads within New Zealand and internationally. The number of downloads by University of Otago medical students overall (Years 4, 5, and 6) has increased since implementation, with peaks correlating with the academic block in which the app is introduced, but continuing throughout the year (Figure 4a).

Cumulative downloads in New Zealand have reached almost 8,000 since app launch, not including uninstalls (Figure 4b).

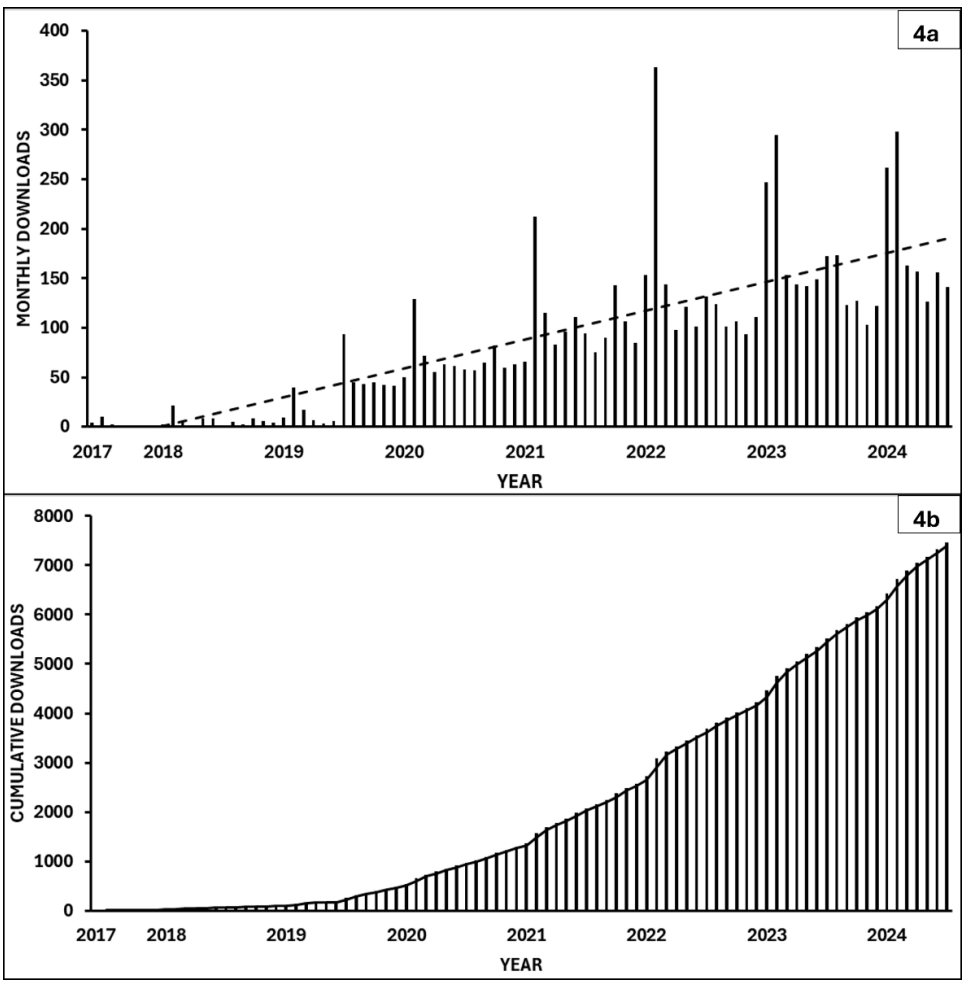

Figure 4: Monthly downloads in New Zealand from the time of implementation (4a), and cumulative downloads in New Zealand (4b) since app implementation (not including uninstalls).

With the Clinical Skills app freely available on the iOS App Store and the Android Play Store, anyone can download it. In July 2023, there were 7,437 international downloads from people in 54 countries, mainly China (37%), New Zealand (23%), and United States (US) (11%). By July 2024, downloads had increased by 104% to 15,193 users from 155 countries, mainly New Zealand (22%), China (18%) and US (10%) (Figure 5). The cumulative active daily users from July 2017 to July 2024 totalled 706,607 across all countries, excluding uninstalls.

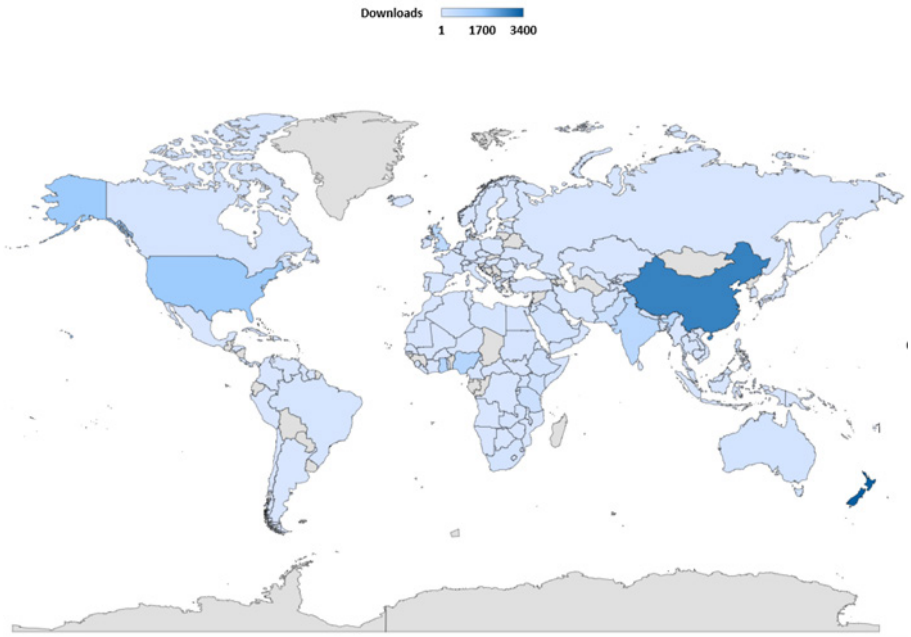

Figure 5: Map of cumulative international downloads in July 2024, not including uninstalls (developed using Excel 365).

DISCUSSION

This article describes the development, usability testing, and implementation of a JITT clinical skills training app for medical students at the University of Otago, New Zealand. Student feedback shows that the app is well received and helpful for their learning, and the continued increase in international downloads indicates a need for such supplemental learning within the broader context of worldwide medical education.

While feedback on the Clinical Skills app was consistently positive, a small number of medical students reported discomfort using it on the wards. This concern has been reported previously, related to perceptions of disengagement/disinterest, students not knowing what they were doing, or phones being used for social reasons within the clinical environment (37–40). Smartphones are ubiquitous and provide a means to organise one's entire work and social life, with the potential to distract from clinical practice rather than supplement it (39,41). However, this should not be considered solely a reflection of the technology, but also of students needing guidance on appropriate use, of the need to update the educational culture within learning environments (39), and of the need to address patient perception. As many as 61% of patients perceive doctors' smartphone use as unprofessional (42), with 22% feeling negative when seeing clinical staff using their smartphones for clinical purposes and 74% feeling negative when they are used for non-clinical purposes (41). By implementing strategies such as the hierarchy of needs regarding mobile technology use developed by Masters et al. (39), the barriers and facilitators to smartphone use among medical students may be addressed across the entire environment in which they learn. Increasing patient awareness of the reasons for student smartphone use, for example, may help improve perceptions and acceptance, enable students to feel more comfortable using devices, and provide guidance on appropriate use and consideration.

There are many challenges to app development, including time, cost, expertise, and the reality that once the app is completed, the process is not finished (43). App development is an iterative process, as seen in the current study, with longitudinal commitment to provide resource updates, new features, and bug fixes, as well as responding to repeat rounds of feedback from end-users (43). An additional consideration is ensuring that apps are accessible to students with different disabilities or learning needs (39,44), including being appropriately formatted to enable text-to-speech options and considering user interaction (39,44,45). However, the development of academic medical centre apps, such as those in the current study, is very different from commercial app development in terms of their goals, funding, and available technical expertise/resources (43). As such, ensuring that apps are accessible to all may be a roadblock until the potential of such an innovative adjunctive education tool is recognised and funded. To increase recognition of the intrinsic value of such apps, decision-support tools to allocate funding for health innovations at academic centres are being developed, as related to consideration of the tertiary value to the institution, novelty, and the potential for adoption and scaling (46). The hope is that this approach may be implemented more frequently and enable increased funding opportunities for development and ongoing management of apps such as in the current study.

The app described and tested in the current study had good uptake by students and was favourably reviewed, thereby acting as a proxy measure of success. However, an important step in the implementation of interventions is testing efficacy among the target audience. While randomised controlled trial (RCT) have been carried out to assess app efficacy among medical students (47), the Clinical Skills app is an optional adjunctive teaching resource that mirrors that taught in the curriculum and as such an RCT would not be justified. However, it is important to carry out further research that implements a formal assessment of objective efficacy of the app as related to student performance, for example: assessing changes in procedural competence, clinical examination performance, or confidence levels prior to, and following, a period of app use. This research should include an assessment of correlations between app usage patterns and student performance to determine whether the frequency of app use, specific procedures, and engagement with videos are related to enhanced skills acquisition. In addition, structuring the collection of future student feedback to include an assessment of perceived efficacy would be beneficial for business-case applications for institutional funding. A validated tool for rating the value of health education mobile apps, the Mobile App Rubric for Learning (MARuL), has been developed. It contains 26 items across four overarching themes: teaching and learning, user-centred, professional, and usability (48). Implementing such an assessment tool in subsequent student cohorts would enable comparisons of value before and after any major changes to the app format or content. It will also allow comparisons between students at different stages of training and between centres using the app. Additional feedback could also gather scored opinions on factors such as the perceived value the app adds to traditional didactic teaching, and the overall learning value (22).

While there are a small number of apps available for medical student clinical skills education, there is great variability in quality, with very little published on the development process or the components included to confirm whether other apps are evidence-based, as is the Clinical Skills app in the current study (49). Apps tend to be focused on specific topics, in contrast to broad clinical skills, as in the current study, with research more commonly assessing satisfaction and perceived usefulness rather than changes in objective skills. One paper reported a pilot study of an app aimed at teaching a cardiovascular module to medical students, which included components such as lectures, slides, interactive modules,

investigations, and tests/competitions (22). This pilot study reported a high rating for the app's potential learning value and high satisfaction when the app was used as an adjunctive teaching method, as in the current study (22). Reporting on the overall picture of clinical skills apps, Khan et al. (50) showed that medical students rated perceived usefulness as high in the domains of improving clinical performance and quick access to medical guidelines, however, many medical colleges did not support their use (50).

Limitations

The Clinical Skills app feedback is from a single tertiary education centre, thereby limiting the generalisability of the results. Expanding use of the app to other campuses in the University where it was developed would allow for additional feedback to be collected to assess between-centre differences. Until the feedback obtained from students is formatted to rate perceived efficacy in improving clinical skills and to determine whether it enhances the current didactic teaching syllabus, the feedback is limited to which sections were most liked and beneficial, and to suggested improvements and procedures. An additional feedback method could include implementing a simple Likert scale at app launch to collect basic feedback on utility from all international users. Until research is carried out to assess objective efficacy of the app, perceived benefits remain subjective and should be taken in such context. When the level of engagement with the app and individual components can also be assessed, this will provide guidance for recommended use.

Strengths

The study included seven years of feedback from medical students using the Clinical Skills app, which has enabled multiple rounds of iterative changes in response to requests and reported issues. This has led to the development of a robust, well-received app that can now be tested in a more formal way to assess perceived efficacy and usefulness. The international reach of the app has provided a proxy measure of utility, an aspect which may now be harnessed to retrieve extensive opinions of whether the app can enhance clinical skills in centres outside where it was developed.

CONCLUSION

The Clinical Skills app was developed with the aim of providing an adjunctive method to teach clinical skills to medical students transitioning to the clinical years of their training. Multiple rounds of iterative development in response to feedback have ensured that the app meets the needs of the students. The international uptake of this open-source app demonstrates that there is a broader need for this adjunctive teaching method. Future directions will gather more structured and comparable data on perceived usefulness, thereby allowing for more in-depth analysis regarding efficacy and value.

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ETHICAL APPROVAL

Ethics approval was provided for use of the retrospective survey results by the University of Otago Human Ethics Committee (25/1290).

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