

Learning and clinical reasoning experience of second-year medical pharmacology students and teachers with virtual patients developed using OpenLabyrinth

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ABSTRACT

Objective: To determine the perceived usefulness of a virtual case scenario developed and delivered through the OpenLabyrinth platform among medical students and teachers.

Methods: 20 second-year medical students and 12 teachers of pharmacology were invited to complete a virtual case scenario exercise. The participants accessed the case scenario using their laptops or mobile devices. Participants' feedback was obtained using the electronic virtual patient consortium-developed questionnaire.

Results: 19 students and 12 teachers provided feedback. All the faculty members and 95% of students felt that they had to make the same decisions a doctor would have to make in real life; 'authenticity of patient encounter' received the highest percentage of positive responses and 'the learning effect' the least.

Conclusions: The feedback obtained suggests that virtual case scenarios are likely to be well received by students and teachers. The availability of open-source software enables the use of this technology in resource-limited settings.

Keywords: learning, virtual patient, technology, medical education, case scenario

INTRODUCTION

As per the Indian regulations on graduate medical education 1997, the medical curriculum is designed to train medical students to attain adequate knowledge and skills to serve as primary care physicians catering to the health care needs of the population [1]. The recently implemented competency-based medical education curriculum, which prescribes changes in the teaching-learning methods as well as student assessment, is aimed toward the same [2]. However, adequate clinical exposure for students to achieve the ultimate objective to be a physician of first contact has always been a challenge. Important constraints include the need for adequate manpower, time management, and availability of clinical resources to achieve the desired objectives. Every student needs to be provided with a comprehensive exposure to the likely common clinical scenarios one is expected to handle as a basic doctor. Since learning is individual-specific, repeated availability of such clinical experiences to the satisfaction of the student needs to be ensured. Integration of the pre/para clinical knowledge acquired during the initial part of the medical curriculum with that during the clinical years is also a challenge to educators. There is a need for a teaching-learning method, which will ensure that knowledge delivery is uniform, with no teacher-to-teacher variation, particularly for the "must-know" areas; continuous, not limited by time; and

complete, as required by the curriculum for that student. Also to be addressed are issues related to patient privacy, safety and comfort are compromised when many students try to interact with and examine a few 'important cases'.

In the above context, overcoming the limitations of time and resources while ensuring uniformity could be achieved by the use of innovative technologies in medical education. Medical simulation is one such innovation, which is being increasingly adopted by many medical schools internationally [3]. In particular, "electronic virtual patients" can potentially be used for training as well as assessment [4]. Virtual patients are computer-based interactive simulations written to mimic the doctor-patient interactions in a clinical setting. In a typical case, the learner is expected to arrive at a diagnosis and select the appropriate treatment measures based on the available data. This has the distinct advantage of providing clinical training to medical students in a risk-free environment, allowing as many repetitions are deemed necessary. This allows the students to acquire the basic skill set, which would complement their bedside training. Since these computer systems can track and store the usage details, this may also be used as a formal documentation of training and tracking student progress [5, 6].

Virtual patient systems usually consist of an authoring and playing tool, providing varying extent of administrative control and facilities for integration with the host information technology infrastructure [5]. In the present study, a virtual

patient system, OpenLabyrinth, was used to author and play the virtual case scenarios [7]. OpenLabyrinth provides a template for the creation of case scenarios with multiple tools for incorporation of images, videos etc., such that the case scenario may range from being simply text-based scenarios to multimedia-rich scenarios. The software is also required for playing the virtual scenario. Being a server-based software, this has the advantage of remote access for case authoring as well as for playing the virtual scenarios (through the user's laptop/desktop/mobile devices) with all the components embedded in a single system on the server. OpenLabyrinth enables the creation of cases with branched decisions [7]. A branched case scenario includes one or more decision points wherein the user is presented with two or more responses to choose from; depending on the responses chosen, the case scenario may proceed in different directions. In a clinical case scenario, different responses may alter the course of the progression of illness, ultimately resulting in a favourable or adverse outcome for the patient [8]. Given the theoretical advantages of electronically delivered interactive branched case scenarios in enhancing the teaching-learning experience, current study aimed to obtain feedback from medical students and teaching faculty regarding their experience of interacting with a virtual case scenario on OpenLabyrinth platform.

METHODS

We conducted a pilot study involving second-year (fifth semester) medical students and teaching faculty of the department of pharmacology of a medical college in India. The study protocol was approved by Kasturba Medical College Institutional Ethics Committee (IEC KMC MLR 08-16/164), and the study was conducted in accordance with the Indian Council of Medical Research National Ethical Guidelines for Biomedical and Health Research. We intended to obtain responses from at least 10 students and 10 faculty members. A preformed virtual

case scenario, developed as part of the pathways for interactive narrative education (PINE) project by the Northern Ontario School of Medicine [9], was used to determine the learning and clinical reasoning experience of the study participants. Virtual case scenarios for evaluation are available as part of the eViP (electronic virtual patients) programme, a collaborative work of multiple universities and co-funded by the European Commission [9].

An important aspect of a virtual case scenario is ability to provide multiple options for users to choose from; for example, given a set of symptoms and signs, a patient may be subjected to one or more laboratory investigations; similarly, based on the patient's response, the pharmacotherapy may remain unchanged or be altered. Branching case scenarios enable the users to choose from multiple options and these, in turn, determine the outcome of the case, with choosing of wrong options resulting in adverse outcomes [8]. Opportunities for mid-way course corrections can also be provided in branching case scenarios (Figure 1). The virtual case scenario chosen for this pilot study consisted of, briefly, a case of an adult male presenting to the hospital with a complaint of headache. The case scenario presents options regarding how the case would be handled, what would be communicated to the patient, and also covers aspects of interprofessional communication. Choosing the right options will prevent the index patient from developing a stroke after his premature exit from the hospital due to a lack of proper communication by the treating health professionals. This case scenario was devoid of any pharmacotherapy aspects. We intentionally chose this case scenario, given that the students and teachers of pharmacology would have expected some drug therapy aspect in the case, which may have potentially led to a positive response bias. The case scenario, which mainly focused on communication with the patient and colleagues, thus, would expose the participants to a scenario not usually discussed as part of the pharmacology curriculum but is an important aspect of patient management.

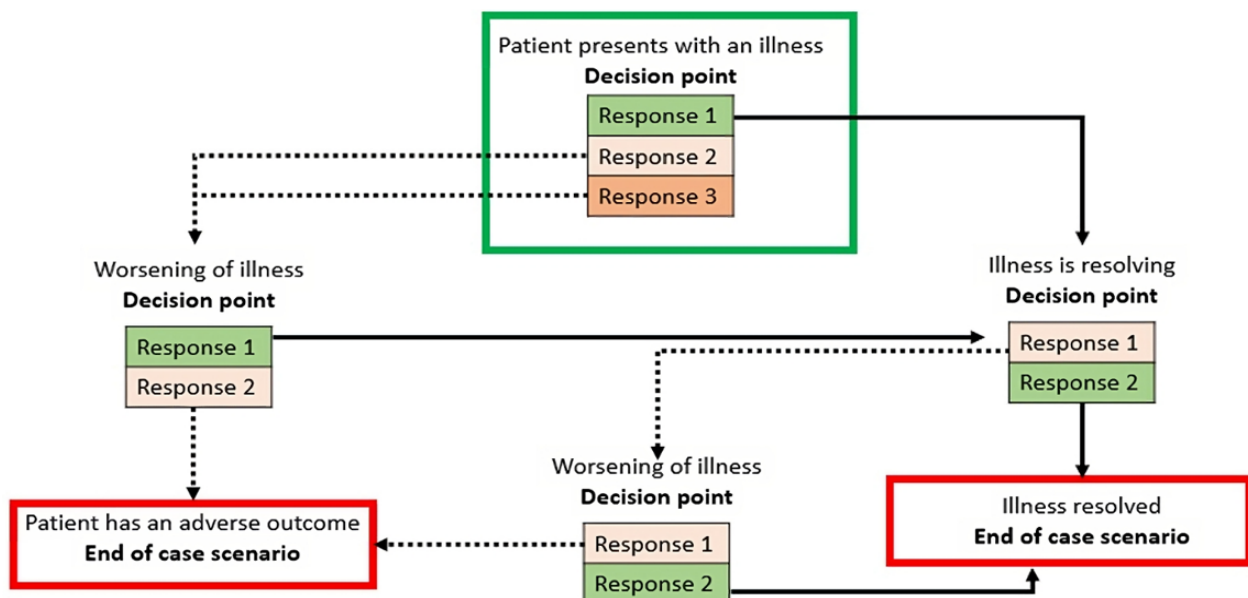


Figure 1. Representation of a branching case scenario (Green-bordered box represents start of virtual case scenario. Decision point presents learners with a question & a set of responses. Depending on response chosen, outcome of case changes. Dotted arrows represent responses chosen that result in worsening of illness or adverse outcome; non-dotted arrows represent responses, which lead to resolution of illness. Red-bordered boxes represent end of case scenario at which point feedback may be presented to learners. As shown, learner can be provided with opportunities to correct an initial wrong decision.) (Source: Authors' own elaboration)

Table 1. Feedback from students & teaching faculty regarding learning & clinical reasoning experience with a virtual case scenario

Statements	Responders*	SD	D	N	A	SA	NA
While working on this case, I felt I had to make the same decisions a doctor would make in real life.	Students	0	0	1	11	7	0
	Teachers	0	0	0	6	6	0
While working on this case, I felt I were the doctor caring for this patient.	Students	0	0	2	11	6	0
	Teachers	0	0	2	7	3	0
While working through this case, I was actively engaged in gathering information (e.g., history questions, physical exams, & lab tests) I needed, to characterize patient's problem.	Students	0	2	6	8	3	0
	Teachers	0	1	1	8	2	0
While working through this case, I was actively engaged in revising my initial image of the patient's problem as new information became available.	Students	0	2	2	12	3	0
	Teachers	0	0	0	6	6	0
While working through this case, I was actively engaged in creating a short summary of the patient's problem using medical terms.	Students	0	0	8	8	3	0
	Teachers	1	1	1	9	0	0
While working through this case, I was actively engaged in thinking about which findings supported or refuted each diagnosis in my differential diagnosis.	Students	0	1	6	10	1	1
	Teachers	0	3	0	4	3	2
I felt that the case was at the appropriate level of difficulty for my level of training.	Students	0	2	6	9	2	0
	Teachers	0	1	1	8	2	0
The questions I was asked while working through this case were helpful in enhancing my diagnostic reasoning in this case.	Students	0	1	6	9	1	2
	Teachers	0	2	1	5	4	0
The feedback I received was helpful in enhancing my diagnostic reasoning in this case.	Students	0	0	3	11	4	0
	Teachers	0	1	2	6	3	0
After completing this case, I feel better prepared to confirm a diagnosis and exclude differential diagnoses in a real life patient with this complaint.	Students	0	5	5	6	0	2
	Teachers	0	3	2	7	0	0
After completing this case I feel better prepared to care for a real life patient with this complaint.	Students	1	2	6	6	4	0
	Teachers	0	0	0	6	6	0
Overall, working through this case was a worthwhile learning experience.	Students	0	0	5	10	4	0
	Teachers	0	0	0	6	6	0

Note. *n=19 for students & 12 for teachers; SD: Strongly disagree; D: Disagree; N: Neutral; A: Agree; SA: Strongly agree; & NA: Not applicable

Table 2. Percentage of positive responses from study participants for five subsets of feedback questionnaire describing various aspects of virtual case scenario

Aspect of virtual case scenario	Percentage of positive response from students (n=19)	Percentage of positive response from teachers (n=12)
Authenticity of patient encounter & consultation	92.11	91.67
Professional approach in consultation	64.47	83.33
Coaching during consultation	66.68	77.75
Learning effect of consultation	47.37	79.17
Overall judgment of case workup	73.68	100.00

The participants accessed the virtual case scenario in the OpenLabyrinth platform (installed on a server) through their laptop/desktop web browsers. Since the purpose was testing and evaluation, the OpenLabyrinth program was installed on a portable server (WAMP server, version 3.2.6) hosted on a local desktop. Feedback was obtained from the participants using a preformed questionnaire, which is part of the evaluation tool kit developed and validated during the eViP European project for the creation and sharing of virtual patients [10]. The questionnaire contains a combination of open-ended and closed-ended questions, which can be clustered into five subsets: authenticity of patient encounter and the consultation, professional approach in the consultation, coaching during consultation, learning effect of consultation, and overall judgment of case workup. Feedback was obtained from the participants using Google forms. Informed consent was obtained from the participants before the study, and no personal identifiers were collected in the questionnaire. The study data has been reported using descriptive statistics.

RESULTS

20 medical students and 12 faculty members were invited to participate in the study; 19 students and all teaching faculty participated in the study and provided feedback. Female participants comprised of 63% and 75% of the student and

faculty study sample, respectively. The response of the students and teaching faculty to the closed-ended questions is shown in **Table 1**.

The percentage of positive responses for the five subsets of the feedback questionnaire is presented in **Table 2**.

With regard to the strengths of the virtual case scenario, the students felt that the case helped them better understand the importance of proper interaction with the patient and consider multiple points of view. One student mentioned "builds up way to interact with patient and communicate things effectively," whereas others stated regarding "multiple point of views" and "interprofessional bonding". Also mentioned were "brought up an important aspect of life as a medical practitioner" and "early stage primary stage with treatment the patient could be cured", which suggest that the case was able to provide an important clinical experience to the participants as well as convey the importance of proper communication in the effective management of a condition.

The teachers expressed that the case emulated a real-life scenario; "real life scenario, very similar to day-to-day experience of a doctor" and "giving a scenario, where real life concerns of the patients are brought up and how they affect the diagnosis and intervention for the patient". One participant also opined that "the case gave a broad perspective of a clinical problem, with an all-round approach involving multiple disciplines."

Table 3. Opinions of teaching faculty regarding authenticity of patient encounter & professional approach in virtual case scenario

Statements	Opinions of teachers (n=12)
Authenticity of patient approach	
While working on this case, I felt I had to make same decisions a doctor would make in real life.	-As it address all issues a common man usually feels during an illness & subsequent approach to healthcare. -Because scenario was very similar to a real-life situation.
	-I agree because doctor made sure that he diagnosed patient condition correctly & also made sure that patient needs to be admitted by taking help from sisters & other professions. Physician main aim is to make sure that patient is managed properly. I feel that his wife should have been informed about his condition. -Can have a similar scenario in future. -He was approaching the patient in a systematic way. -In real life also a doctor comes across similar situations.
While working on this case, I felt I were doctor caring for this patient.	-Important decisions were to be made and hence made me the person in charge.
	-Case scenario is simple & feels real. It reminds us usual problems faced by doctors in communicating with stressed out patients. -Because it was all up to my decision. -Because I saw similar cases, where patient & attender both are tensed & they do not understand situation.
Professional encounter	
While working through this case, I was actively engaged in gathering information (e.g., history questions, physical exams, & lab tests) I needed, to characterize patient's problem.	-As the case scenario unfolded the pertinent information was provided. -There was no opportunity for thinking about history-taking, physical exam, or lab tests. -Because it's necessary for appropriate diagnosis and treatment. -I was getting information one by one, to arrive at the diagnosis.
	-Initially felt it was a stress headache and later lab tests signified stroke.
While working through this case, I was actively engaged in revising my initial image of patient's problem as new information became available.	-As the scenario progressed the pain did not improve; after the diagnosis of stroke was confirmed, my initial image of the patient's problem changed. -Patient headache was initially considered a stress induced headache & then it was diagnosed as a stroke. -So that the treatment can be given for all aspects of the scenario.
	-It was a severe headache, later loss of balance in patient made me think differential diagnosis of headache. -As there was progressive disclosure.
While working through this case, I was actively engaged in creating a short summary of patient's problem using medical terms.	-Case scenario did not prompt me to do so.
	-Scenario was more about interpersonal relationship, building a rapport and working as a member of a wider health-care team than learning about stroke. -Helps me to know the correctness of my intervention. -Stroke, resistant patient.
While working through this case, I was actively engaged in thinking about which findings supported or refuted each diagnosis in my differential diagnosis.	-Not much to base differential diagnosis.
	-Scenario was more about interpersonal relationship, building a rapport and working as a member of a wider health-care team than learning about stroke. -To know if I am going in correct direction or not. -Extra investigations and case history should be provided.

Regarding the weaknesses of the virtual case scenario, the students opined that the treatment aspect was not covered in the case. Some of the statements were “no mention of treatment modalities”; “the treatment was not a part of the case”; “please put one more medically relevant question for e.g.,: arriving at the drug to be used or the next plan of action”. The lack of information/assessment regarding the treatment aspect was also pointed out by the teaching faculty: “no therapeutic training”; “what type of stroke was not mentioned”; “could not get an overview of the pharmacotherapy”. Some teachers also felt that the presentation of the case could have been improved: “linking up of choices can be improved in few slides” and “after the second link, going back to home page was a little confusing.”

The responses provided by the teaching faculty for the open-ended questions concerning each of the statements in the questionnaire are listed in [Table 3](#) and [Table 4](#).

DISCUSSION

In this study, we piloted a virtual branched case scenario using the OpenLabyrinth case authoring and presentation platform among a group of second-year medical students and teaching faculty of pharmacology. All the faculty and 95% of the students opined that the virtual case scenario required

them to make the same decisions a doctor would have to make in real life; 83% of the faculty and 90% of the students felt that they were the doctor caring for the patient. All the faculty and 53% of the students felt that after completing the case scenario they were better prepared to handle a similar case; 32% of the students were neutral while the rest disagreed, indicating a difference in the perceived usefulness of the exercise among teachers and students. This can probably be explained by the fact that the students expected the case scenario to involve pharmacotherapy aspects, as is apparent from their comments regarding the weaknesses of the virtual case scenario. Although the teacher participants also mention this aspect regarding the absence of emphasis on the treatment aspect, they were probably able to perceive the importance of proper communication and ethical behaviour in patient care. In fact, this has been one of the criticisms of the medical education curriculum, which does not adequately emphasize the ethical and behavioural aspects of patient care. The revised curriculum to a large extent has taken cognizance of this issue and incorporated relevant modules in the teaching curriculum, right from the first year of medical education [2]. Availability of such virtual case scenario authoring tools will help to convey these difficult-to-teach soft skills to students in an experiential learning environment. This is supported by finding that all the teaching faculty and 74% of the students felt that answering virtual case scenario was a worthwhile experience.

Table 4. Opinions of teaching faculty regarding coaching & learning effect during interaction with virtual case scenario & overall judgment

Statements	Opinions of teachers (n=12)
Coaching during consultation	
I felt that case was at appropriate level of difficulty for my level of training.	<ul style="list-style-type: none"> -Students need to understand patients' perspective & use of soft skills while dealing with a patient. -Here patient had severe headache, followed by loss of balance. Loss of balance indicates higher function involvement. He is above 40 yrs, stressed out, unhappy, male gender-which are risk factors for stroke. A CT scan might initially rule out a case of stroke. -Practical knowledge testing was appropriate.
Questions I was asked while working through this case were helpful in enhancing my diagnostic reasoning in this case.	<ul style="list-style-type: none"> -Questions were designed meaningfully. -The scenario was more about interpersonal relationship, building a rapport and working as a member of a wider health-care team than learning about stroke. -The questions were not mono-directed. It gave the participant to understand what the various options were, and which one is the best. -Need to have a better understanding of the mental status of the patient. -More details of clinical examination finding could be provided.
Feedback I received was helpful in enhancing my diagnostic reasoning in this case.	<ul style="list-style-type: none"> -Feedback helped me to redirect my way of thinking. -The scenario was more about interpersonal relationship, building a rapport and working as a member of a wider health-care team than learning about stroke. -To know where I went wrong and how to correct.
Learning effect	
After completing this case, I feel better prepared to confirm a diagnosis & exclude differential diagnoses in a real life patient with this complaint.	<ul style="list-style-type: none"> -Need a lot more study and practice for this. -The scenario was more about interpersonal relationship, building a rapport and working as a member of a wider health-care team than learning about stroke. -A headache should not be taken lightly. Other negative histories supporting stroke should be asked and CT is required if the headache is associated with other signs and is not relieved by Tylenol. -Need more experience practically till I am well versed in the diagnosis. -Loss of balance in this patient should be considered for involvement of brain, possibility of stroke. -Multidimensional approach to healthcare was reiterated.
After completing this case, I feel better prepared to care for a real life patient with this complaint.	<ul style="list-style-type: none"> -Better prepared to convince a non-compliant patient and to take the help from my colleagues. -Sisters are of great help in communicating with some resistant patient. -Better understanding and better knowledge about the case. -Communication is very important. Some patients are better counseled by nurses.
Overall judgment	
Overall, working through this case was a worthwhile learning experience.	<ul style="list-style-type: none"> -Helped to understand patient as a whole rather than merely a case. -Interdependent professions. It is necessary to take help from nurse and other profession, if you think that can help patients life. -Gaining new aspects of stroke in a real life scenario. -The case was interesting.

The above findings indicate the usefulness of virtual case scenarios in addressing an important felt need in the medical curriculum of ensuring early clinical exposure in a graded manner from the beginning of the first professional year and also emphasizing the applied aspects of the pre- and para-clinical disciplines. Importantly, such simulated exposure can be made accessible to students as and when required, overcoming a major drawback of teaching in a clinical environment or bedside teaching. This also ensures that when the medical student does interact in a real clinical setting, he/she has acquired at least the basic thinking and reasoning skills, thereby ensuring better utilization of the available clinical resources. Globally, virtual case scenarios have been used to varying extent [11]. Its use in the Indian institutions is fraught with concerns regarding the infrastructure, development costs, and integration into the curriculum, which until recently had very little in terms of encouraging such attempts. Cost and infrastructure are real concerns in resource-limited settings; although the lack of need for instructors or patients would be expected to drastically decrease the cost of teaching, the real costs involved in developing and hosting the learning materials are unclear [12]. Many case authoring and publishing software are available. The level of sophistication of the case scenarios developed would depend on the teaching-learning objectives as well as the user feedback regarding the presentation of the learning material, which can significantly affect the costs.

Regarding the utility of such virtual case scenarios, similar to the positive response observed in our study, several other investigators have reported favorable feedback from the learners. It was developed a set of virtual case scenarios using a locally developed virtual patient authoring and playing system to teach anaesthesia and patient care [6]; the cases were well received by students and helped overcome the challenges in providing adequate clinical exposure. Peng et al. compared conventional teaching methods to virtual case simulation combined with problem-based learning in 300 medical students learning paediatrics [13]; students in the latter group showed better academic performance, knowledge, and comprehensive ability. It was assessed the impact of an interprofessional virtual patient module and found that it improved communication between the participants and helped them understand their role as well as those from other disciplines in patient care [14]. A similar study using a virtual patient case was also conducted among medical students alone; the exercise provided the participants with an insight into team collaboration and understanding of the role of other health professionals [15]. It was tested the usefulness of virtual patients in preclinical pharmacology teaching among third year medical students; compared to the traditional tutorials, the virtual patient-based tutorials led to better performance in examination and facilitated learning [16]. Richardson et al. performed a systematic review of the use of virtual patients among pharmacy students. Virtual patients

were found to be useful in pharmacy education although the extent of such benefits could not be ascertained due to the studies involving small sample sizes with varying study designs [17]. Studies evaluating use of virtual patients among the allied health professionals have also found encouraging results [18, 19]. However, not all investigators have found substantial benefits with the use of virtual case scenarios [20]. It was conducted a multicentric pilot study assessing the agreement between standardized patient and virtual patient assessments for evaluating primary health care quality [21]. The agreement between the two evaluation methods was low with the virtual patient results being affected by the design, usability and case conditions [21].

When properly implemented, virtual case scenarios not only help in providing a better user learning experience in a time-independent manner but also provide an opportunity to understand the areas, where a learner is not performing well. The ability to track the decisions taken by the learner in solving the case scenario can be used to identify areas of learning requiring reinforcement [22]. The development of standard guidelines for creating an electronic virtual patient also enables sharing of such case scenarios between institutions, which can address the issue of cost and time involved in the development of good quality case scenarios [23, 24].

Our study has limitations. The small group of participants in this study may probably have been those who were likely to use alternate learning methods, and hence, have favourable opinions towards the same. While we assessed the learners' response to the virtual case scenario, the study did not take into consideration the possible challenges with regard to setting up the infrastructure for large scale use or handling any technical errors that are likely to arise. Such challenges can hamper the uptake of such teaching-learning modalities in institutions without adequate resources. Also, although the responses recorded in the study were related to how the learners perceived the virtual case scenario, the extent of success to a large extent depends on how the cases are constructed in terms of knowledge and logic, the presentation, and tailoring it to match the knowledge level of the learners.

CONCLUSIONS

Our study showed that the overall experience of students and teachers in interacting with a virtual case scenario was positive; the participants felt that the case scenario provided them with a broader perspective of patient care and understanding of the role of other health professionals. Virtual case scenarios developed using the OpenLabyrinth system can provide the experience of clinical scenarios in a virtual, risk-free environment to medical students, and thereby, provide a unique learning experience supplementing the existing methods of learning even in resource-limited settings.

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Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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