Ind. J. Pharm. Edu. Res., 2024; 58(3):931-939.
https://www.ijper.org

Original Article

Association between Clinical Case Validation and Students' Success Rate in Virtual Pharmacy Simulation

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ABSTRACT

Background: Virtual simulation has been widely used in various pharmacy educational institutions worldwide, and it helps students approach the real-world pharmacy practice experience. However, the importance and practice of validating clinical cases among pharmacy educators still need to be improved. **Objectives:** To assess the correlation between the success rate of students with reliability statistics, Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). **Materials and Methods:** One hundred and fifty students completed the twenty case scenarios comprising patient interviews, medication labeling, and counseling tasks. Students were randomly divided into an exam group (75 students) and a validation group (75 students). In the exam group, student passes percentages and the mean number of successes and failed students were calculated and compared using the students '*t*-test. Reliability statistics, EFA, and CFA, were performed in the validation group to validate the clinical case scenarios. Spearman's correlation was used to assess the correlation between the pass percentage of students and Reliability statistics, EFA, and CFA. **Results:** The pass percentage of students had a significant positive correlation ($p<0.05$) with Cronbach's α, McDonald's ω percentage of variance, initial Eigen value, Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). Also, the Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square (SRMR) had a significant negative correlation ($p<0.05$) with the pass percentage of students. All these findings authenticate the relationship between the reliability, EFA, and CFA, and validated clinical cases significantly impact the pass percentage of students. **Conclusion:** Pharmacy educators should ensure the validation of clinical cases, as validated clinical cases can enhance the learning experience. This may help to uplift the pharmacy practice experience and education.

Keywords: Correlation, Confirmatory factor analysis, Exploratory factor analysis, MyDispense, Pass percentage of students, Reliability statistics, Virtual simulation.

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Received: 15-03-2023;
Revised: 12-01-2024;
Accepted: 28-05-2024.

INTRODUCTION

In pharmacy education, simulation plays a vital role in training students to acquire pharmacy practice experience.[1,2] It has been described as a suitable medium for optimal transition from theoretical to practice settings[3] and in developing pharmacy practice skills among pharmacy students.[4] Moreover, pharmacy simulation was considered a safe environment to learn pharmacy practice skills without causing harm to the patients.[5] Recently, virtual placement programs have been introduced in several pharmacy schools across the world to provide pharmacy setup-like real-life scenarios for pharmacy students.[5] The Faculty of Pharmacy and Pharmaceutical Sciences at Monash University, Melbourne, Australia, introduced a virtual hospital pharmacy program named MyDispense in 2011, which helps train students toward patient-centred pharmaceutical care.[6] MyDispense was a known platform for collaborating pharmacy educators to enhance the quality of the pharmacy practice curriculum.[7] This virtual simulation experience encouraged the students to obtain relevant skills for hospital pharmacy practice such as drug dispensing, communication and patient care and safety.[8] Recently, a study reported that the students could handle the cases successfully and there was no significant difference

DOI: 10.5530/ijper.58.3.102

in students' perception of virtual simulation and real-life pharmacy practice experience.[9] Another study emphasizes that MyDispense was a feasible assessment method that could assess student performance rapidly.[10] The virtual simulation was used widely in various schools of pharmacy across the world and many reports have been published related to community pharmacy practice,[5,11] student perspectives,[9,12] case study design,[13] dispensing,[8] controlled substances,[14] and usefulness during the COVID-19 pandemic.[7] Previous researchers warranted a new tool to validate the clinical cases in the simulation setup.[15] A comprehensive validation procedure was recently established in an objective structured simulation in a community pharmacy.[16] However, knowledge of the importance of clinical case validation and its impact on student's success rate in virtual simulation is yet to be established. Considering the above uncertainties, the present study aimed to investigate the association between the pass percentage of students and the validation of multimedia computer-based interactive patient scenarios.

MATERIALS AND METHODS

Subjects

A total of 150 male and female Doctor of Pharmacy (Pharm D) students enrolled in the fourth year in 2021-22 and registered in the Introductory Pharmacy Practice Experience 2 course. They were randomly divided equally to validate (validation group) and to assess the success rate (exam group) using a split-it-at-random method.[17] The course comprised lectures and simulation exercises, including patient interviews, medication labeling and counseling tasks.

Development of Case Scenarios

The course instructors created 20 clinical case scenarios. To reflect the real-world scenario, the contents of the cases were derived from outpatient pharmacies at local hospitals of the Ministry of Health. The case scenarios included patient information related to demographics and diseases. They recommended medications to enable students to interact and utilize their pharmacology knowledge, dispensing and counseling skills on medications and drug interactions. The learning objectives of each exercise were intended to evaluate students' cognitive abilities such as problem-solving capacity and prescription-monitoring ability.

Peer Review of Case Scenarios

Content validity refers to whether the items of the cases and questions were developed to represent the subject of assessment. The contents of all case scenarios were peer-reviewed by four faculty members in the Department of Pharmacy Practice through a feedback form rating their perceptions of the adequacy of the interactive content of cases. The form was modified from Gupta *et al.* (2017)[18] and included closed-ended questions on a five-point Likert scale. The cases were revised based on faculty agreement scores. Then, the course instructors uploaded and released the case scenarios in the MyDispense virtual simulation database and formulated the exercises as assignments to students.

Virtual Simulation and Exercises

The course instructors created an account in MyDispense for all the students using their full names and academic emails. The course instructors arranged tutorials to provide the students the required technical and professional demonstration regarding the completion of exercises and the handling of the case scenarios. Afterwards, the students were asked to access the tutorials and attempt the exercises using desktops. The course instructors immediately resolved all the queries rose by the students and ensured that the students had sufficient exposure to MyDispense exercises. All 20 virtual simulation exercises were freely accessed in a computer laboratory with all the required facilities during the scheduled timetable for male and female students.

Evaluation of Exercises

The exercises were evaluated using three different but equally weighted components: patient interviews, medication labeling and patient counseling. In the patient interview part, students were supposed to interact with the virtual patients and collect relevant data by choosing from a list of 12 questions before dispensing the issued prescription. The questions were designed based on the gender, age, diagnosis, pregnancy status and lactation status of the patient. The objectives of this part of the scenario were to prepare students to be assertive, use effective questions and integrate the patient's perspective in the medication management process.

In the medication labeling part, the students were expected to label the prescribed medications correctly. The toolbar of MyDispense allows the students to prepare the appropriate label with all details about the medication regimen and paste it on the medication box. Finally, the student should write the necessary instructions about the optimum use of medications in the free text entry of the software while labeling the medicines.

The students were awarded 5 marks upon the successful completion of each part. Therefore, the final exercise score was calculated as the sum of all three parts, with a maximum of 15 marks, as the student progressed through the exercise. The cut-off score for success in the exercises was determined as 60% based on the university policy.

Data Analysis

Reliability statistics for internal consistency

Reliability or internal consistency would measure the reproducibility of the assessment scores from one batch of students to another if the assessments were repeated later.[19] The reliability of the developed cases was assessed with the calculation of Cronbach's α and McDonald's ω coefficients. The Cronbach's α

and McDonald's ω coefficients >0.7 were considered acceptable internal consistency.[20,21] Because the three parts of the assessment are typically nested in a case, the total scores of each student for each of the three parts of the scenario were used to determine reliability.[19]

Exploratory Factor Analysis (EFA)

EFA was conducted to assess the extent to which the three components of each case scenario relate to the case construct. The sample size adequacy was measured using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test for sphericity. A KMO value >0.5 was acceptable for sampling adequacy. A p value <0.001 was considered statistically significant for Bartlett's test for sphericity.[22] An Eigenvalue[23] >1 and a percentage of variance[24] >50.2% were considered threshold values. The factor loadings >0.3 denoted a moderate correlation between the items and the factors.[25]

Confirmatory Factor Analysis (CFA)

CFA of the three components of the case scenarios (exercise score) was conducted to confirm the internal structure of the cases. Several goodness-of-fit statistics for exact fit and fit indices were used to assess the degree to which case scenario items fit the evaluation. A chi-square test with p>0.001 indicates the overall goodness of fit model (maximum likelihood) for the corresponding case scenario. Other tests such as the root mean square error of approximation (RMSEA<0.08), Comparative Fit Index (CFI>0.95), Tucker-Lewis Index (TLI>0.95), Standardized Root Mean Square (SRMR<0.08) and $\chi 2/df$ (< 5) authenticates the good model fit.[26,27]

Correlation between Percentage of Successful Students and Reliability Statistics, EFA and CFA

The correlation coefficient of Spearman's rho test was used to assess the validity evidence for the relationship between the percentage of successful students with reliability statistics, EFA and CFA. p<0.05 was considered a statistically significant association between them.

Statistical Software

All statistical analyses were done using the Statistical Package for the Social Sciences (SPSS; version 25.0) AMOS and *JAMOVI* databases.

Table 1: Number of students succeeded and percentage of pass in each exercise.

	Number of students succeeded*	Number of students failed**	Student pass percentage
Case 1	70	5	93.33
Case 2	39	36	52
Case 3	65	10	86.66
Case 4	75	0	100
Case 5	62	13	82.66
Case 6	69	6	92
Case 7	67	8	89.33
Case 8	56	19	74.66
Case 9	64	11	85.33
Case 10	72	3	96
Case 11	61	14	81.33
Case 12	56	19	74.66
Case 13	40	35	53.33
Case 14	64	11	85.33
Case 15	70	5	93.33
Case 16	43	32	57.33
Case 17	65	10	86.66
Case 18	62	13	82.66
Case 19	54	21	72
Case 20	64	11	85.33
Mean (SD)	60.90 (10.23)	14.10 (10.23)	
p value	0.0001		

*The students achieved the actual outcome considered as succeeded students;**The students achieved the wrong outcome considered as un succeeded students;Paired 't' test between succeeded and un succeeded students with the p value<0.05 considered as significant.

Table 2: Reliability statistics.

	Patient interview		Labeling		Counseling	
	Cronbach's α	Mc Donald's ω	Cronbach's α	Mc Donald's ω	Cronbach's α	Mc Donald's ω
Case 1	0.866	0.871	0.851	0.863	0.942	0.943
Case 2	0.816	0.829	0.792	0.848	0.594	0.589
Case 3	0.817	0.832	0.897	0.901	0.971	0.975
Case 4	0.944	0.944	0.955	0.959	0.898	0.908
Case 5	0.876	0.884	0.881	0.895	0.814	0.825
Case 6	0.948	0.953	0.985	0.988	0.874	0.911
Case 7	0.951	0.952	0.958	0.960	0.862	0.900
Case 8	0.880	0.891	0.994	0.994	0.762	0.794
Case 9	0.938	0.941	0.866	0.875	0.968	0.969
Case 10	0.900	0.901	0.948	0.952	0.960	0.961
Case 11	0.882	0.892	0.830	0.833	0.828	0.869
Case 12	0.838	0.851	0.784	0.830	0.717	0.751
Case 13	0.815	0.829	0.784	0.793	0.562	0.598
Case 14	0.882	0.886	0.844	0.880	0.922	0.929
Case 15	0.943	0.946	0.937	0.942	0.966	0.967
Case 16	0.668	0.714	0.815	0.853	0.312	0.536
Case 17	0.810	0.827	0.762	0.783	0.906	0.913
Case 18	0.888	0.896	0.845	0.857	0.916	0.927
Case 19	0.930	0.935	0.793	0.801	0.788	0.820
Case 20	0.877	0.885	0.732	0.764	0.871	0.877

RESULTS

Students' Pass Percentage

More than 90% of students succeeded in five exercises (cases 1, 4, 6, 10 and 15), followed by 80 to 90% of students who succeeded in nine exercises (cases 3, 5, 7, 9, 11, 14, 17, 18 and 20) and 70 to 79% succeeded in three exercises (cases 8, 12 and 19). However, less than 60% of students succeeded in three exercises (cases 2, 13 and 16). The mean number of students who succeeded was higher (60.9) than the failed students (14.1) and this difference was statistically significant (p=0.000) (Table 1).

Reliability Statistics for Internal Consistency

Table 2 describes the reliability statistics to assess the internal consistency for patient interviews, medication labeling and counseling tasks. Patient interview and medication labeling tasks had acceptable reliability for all the exercises, since the Cronbach's α and McDonald's ω coefficients were >0.70. Three exercises (cases 2, 13, 16) had unacceptable reliability regarding the patient counseling task.

Exploratory Factor Analysis (EFA)

Table 3 shows the results of exploratory factor analysis for all exercises. All exercises had initial Eigen values >1. The percentage of variance was >50% in most of the exercises except case 14 (49.57) and 16 (42.5). The value of Bartlett's test for sphericity was <0.001 in all the exercises for the corresponding tasks. The KMO-MSA was acceptable (≥0.5) in all cases. Factor loadings were found to be >0.3 in all the case scenarios; therefore, it was not mentioned in Table 3.

Confirmatory Factor Analysis (CFA)

According to the tests for an exact fit, only three cases (1, 4 and 10) demonstrated goodness of fit with p>0.001. Most of the cases have acceptable SRMR (<0.08) and few cases have acceptable CFI (≥0.95). However, only case 4 had a good fit model (χ^2=2.33; p=0.312; TLI=0.994; RMSEA=0.047; SRMR=0.022; CFI=0.998 and χ2/df=0.466 (Table 4) and the students' pass percentage was 100% (Table 4).

Correlation of Percentage of Pass with Reliability Statistics, EFA and CFA

Students' pass percentage positively correlated with Cronbach's α and McDonald's ω in all three tasks, including patient interview, medication labeling and counseling (Table 5). This association was statistically significant (p<0.05). In EFA, the percentage of variance and initial Eigen value had a significant positive correlation (p<0.05) with the pass percentage of students;

Table 3: Exploratory factor analysis.

	Patient interview				Labeling				Counseling			
	Percentage of variance	Initial Eigen value	Barlett's test for sphericity	KMO-MSA	Percentage of variance	Initial Eigen value	Barlett's test for sphericity	KMO-MSA	Percentage of variance	Initial Eigen value	Barlett's test for sphericity	KMO-MSA
Case 1	58.2	2.910	<0.001	0.891	57.8	2.887	<0.001	0.747	77	3.848	<0.001	0.891
Case 2	50.7	2.535	<0.001	0.715	53.7	2.684	<0.001	0.697	57.3	2.868	<0.001	0.500
Case 3	51.5	2.572	<0.001	0.691	64.6	3.230	<0.001	0.864	46.6	2.328	<0.001	0.500
Case 4	77.3	3.863	<0.001	0.500	82.6	4.130	<0.001	0.500	67.9	3.397	<0.001	0.500
Case 5	63.4	3.168	<0.001	0.500	65.7	3.284	<0.001	0.500	53.1	2.676	<0.001	0.500
Case 6	80.6	4.032	<0.001	0.500	94.2	4.714	<0.001	0.500	68.4	3.418	<0.001	0.500
Case 7	79.9	3.997	<0.001	0.834	82.9	4.143	<0.001	0.500	66.2	3.312	<0.001	0.797
Case 8	63.1	3.153	<0.001	0.500	97.2	4.861	<0.001	0.500	88.8	4.441	<0.001	0.500
Case 9	76.6	3.828	<0.001	0.500	60.2	3.013	<0.001	0.500	86.4	4.317	<0.001	0.500
Case 10	64.8	3.237	<0.001	0.813	79.8	3.989	<0.001	0.500	83.0	4.152	<0.001	0.500
Case 11	64.1	3.206	<0.001	0.692	59.4	2.643	<0.001	0.632	59.6	2.981	<0.001	0.732
Case 12	55.5	2.777	<0.001	0.535	52.6	2.630	<0.001	0.500	75.0	3.749	<0.001	0.500
Case 13	51.8	2.587	<0.001	0.581	46.8	2.381	<0.001	0.500	71.7	3.583	<0.001	0.854
Case 14	61.2	3.058	<0.001	0.669	45.4	2.271	<0.001	0.740	42.1	2.070	<0.001	0.500
Case 15	83.0	4.149	<0.001	0.500	76.4	3.820	<0.001	0.500	85.3	4.265	<0.001	0.500
Case 16	37.8	1.906	<0.001	0.762	60.2	3.009	<0.001	0.500	29.5	1.472	<0.001	0.574
Case 17	50.3	2.515	<0.001	0.880	46.3	2.371	<0.001	0.682	69.5	3.478	<0.001	0.500
Case 18	64.8	3.241	<0.001	0.500	56.8	2.852	<0.001	0.500	35.1	1.780	<0.001	0.581
Case 19	74.4	3.721	<0.001	0.500	46.7	2.335	<0.001	0.500	49.6	2.480	<0.001	0.691
Case 20	60.6	3.031	<0.001	0.848	42.7	2.136	<0.001	0.500	58.9	2.943	<0.001	0.676

Table 4: Confirmatory factor analysis.

	Test for exact fit			Fit measures			
	χ2	df	P	RMSEA	CFI	TLI	SRMR
Case 1	10.3	5	0.067	0.119	0.972	0.943	0.035
Case 2	1973	5	<0.001	0.528	0.166	0.026	0.174
Case 3	76.7	5	<0.001	0.437	0.667	0.333	0.107
Case 4	2.33	5	0.312	0.047	0.998	0.994	0.022
Case 5	18.5	5	<0.001	0.331	0.952	0.856	0.036
Case 6	90.7	5	<0.001	0.104	0.909	0.917	0.073
Case 7	25.4	5	<0.001	0.233	0.950	0.901	0.022
Case 8	1314	5	<0.001	1.890	0.217	0.565	0.103
Case 9	10	5	0.007	0.231	0.861	0.583	0.072
Case 10	11.2	5	0.048	0.129	0.965	0.929	0.033
Case 11	47.6	5	<0.001	0.337	0.827	0.655	0.049
Case 12	149	5	<0.001	0.619	0.565	0.131	0.162
Case 13	1275	5	<0.001	2.910	0.177	0.470	0.060
Case 14	129	5	<0.001	0.575	0.666	0.333	0.149
Case 15	40.5	5	<0.001	0.308	0.810	0.619	0.052
Case 16	1266	5	<0.001	1.830	0.185	0.630	0.130
Case 17	20.9	5	<0.001	0.206	0.910	0.820	0.074
Case 18	23.7	5	<0.001	0.223	0.811	0.623	0.106
Case 19	74.1	5	<0.001	0.429	0.683	0.367	0.146
Case 20	67.1	5	<0.001	0.408	0.750	0.499	0.090

meanwhile, KMO-MSA has no significant association with the pass percentage of students. CFI and TLI have significant ($p<0.05$) positive correlations; however, both the RMSEA, SRMR and χ2/df had significant ($p<0.05$) negative correlations with the pass percentage of students. These correlations indicate that the validation of clinical cases significantly influenced students' performance.

DISCUSSION

The simulation in pharmacy education based on valid virtual patient case scenarios provides students with opportunities to practice dispensing and medication verification skills develop problem-based learning skills and bridge the gap due to the lower exposure to actual patients in their preclinical years.

This study provided the initial validity evidence for the correlation between the students' pass percentage and the reliability statistics, EFA and CFA from multimedia computer-based patient scenarios. This was the first trial for validating medication-related simulation exercises in the Pharm D curriculum. The development of the case scenarios was based on actual patient data from the outpatient pharmacies of local hospitals to simulate a real clinical environment and support the validity measures. The adoption from actual practice ensures that the cases are relevant to the community and that the appropriate medications are available in the market. We implemented this practice which was already well-established in pharmacy education.[28,29] The previous investigators in pharmacy education already attempted validation of clinical cases; however, this is the first study to establish the importance of clinical case validation in virtual simulation.[16,30] The biggest challenge to implementing efficient virtual pharmacy simulations was the time required to create and validate the case scenarios. In this regard, the collaborative help of the faculty members supported the development and validation of the cases. The content validity of the developed scenarios was assessed by faculty members writing the cases and questions and revised after peer review. The results showed that 95% of the intended pharmacy practice skills were addressed by the assessment. The success in content validity provides initial justification for conducting reliability statistics and factor analysis.[31]

In counseling domain, the internal consistency of three cases was poor and the remaining was acceptable. Further, interview and dispensing demonstrated acceptable internal consistency in our reliability analysis of the three tasks examined. This gave the green light to carry out further factor analysis.[32,33]

For EFA analysis, the value of Bartlett's test for sphericity was <0.001 in all the exercises for the corresponding tasks, indicating a fit matrix layout for factor analysis. However, a low KMO-MSA value with no correlation with the students' pass score in most

Table 5: Correlation of percentage of succeeded students with reliability statistics, Exploratory factor analysis and fit measures.

Variables	Spearman's rho	*p* value
Reliability statistics		
Patient interview		
Cronbach's α	0.545	0.007
Mc Donald's ω	0.532	0.008
Labeling		
Cronbach's α	0.549	0.006
Mc Donald's ω	0.528	0.008
Counseling		
Cronbach's α	0.771	< .001
Mc Donald's ω	0.773	< .001
Exploratory factor analysis		
Patient interview		
Percentage of variance	0.510	0.011
Initial Eigen value	0.502	0.012
KMO- MSA	0.110	0.322
Labeling		
Percentage of variance	0.416	0.034
Initial Eigen value	0.446	0.024
KMO- MSA	0.060	0.401
Counseling		
Percentage of variance	0.326	0.080
Initial Eigen value	0.326	0.080
KMO- MSA	-0.201	0.802
Fit measures		
RMSEA	-0.805	<0.001
CFI	0.801	<0.001
TLI	0.669	<0.001
SRMR	-0.651	<0.001

cases was noted, indicating poor sampling adequacy for analysis, likely due to low sample size. This result attests to the need for a larger sample size for the reliability and validity analyses.[34,35]

Factor analysis has been advocated as a standard tool to determine the Objective Structured Clinical Examination (OSCE) in a medical school.[36-38] CFA testing revealed that only three cases (1, 4, and 10) were fit for evaluation. This is mainly based on CFA but is not a good fit for authentication analysis using RMSEA, CFI, TLI, and SRMR.[39] When good fit authentication was applied through various fitness measures, only one case demonstrated a good fit model for evaluation in our analysis.[40]

The high-quality designed virtual scenario is fundamental to promoting the learning process and improving learner performance and satisfaction.[41] Validating, revising and increasing the virtual case complexity enhances the behavioural, affective and cognitive domains of engagement in online learning on the part of the students.[42] A valid, highly technical virtual patient scenario enhances the clinical reasoning skills and the student attitudes for attending to real patients. It was reported that the exam scores and the student achievements were positively improved when MyDispense was integrated into a therapeutics course[10] and the case validation exercises in the pharmacy law course[14] and the community pharmacy course.[43] Virtual simulation allows the course instructors to download the results in Microsoft Excel format; hence the validation of the clinical case scenarios might prove easier as the data is available spontaneously.

LIMITATIONS

The findings of this study were based on the data analysis of a sample recruited from a single School of Pharmacy. The findings are limited in generalizability to other pharmacy schools with students of diverse multicultural backgrounds. The four faculty members rating the content validity of the scenarios were from the same institution; thus, there is a potential scoring bias. However, the reviewers expressed their attitudes and beliefs as shared instructors who will utilize these virtual scenarios in future course teaching.

CONCLUSION

The validation of the case scenarios on MyDispense was correlated with better student performances and a high success rate in examinations. Hence this study recommends that pharmacy educators use virtual simulation to perform the validation of clinical cases to rule out the pitfalls in case construction as well as to improve student performance.

FUNDING

The authors extend their appreciation to the Deanship of Research and Graduate Studies at the University of Tabuk for funding this work through Research No. S-1443-0034.

ACKNOWLEDGEMENT

We are also thankful to Monash University, Australia, for partnering with the University of Tabuk to utilize MyDispense to train pharmacy students in various aspects (https://info.mydispense.monash.edu/community/partner-institutions/).

CONFLICT OF INTEREST

The authors declare that there is no conflicts of interest.

ABBREVIATIONS

EFA: Exploratory Factor Analysis; **CFA:** Confirmatory Factor Analysis; **CFI:** Comparative Fit Index; **KMO:** Kaiser-Meyer-Olkin; **RMSEA:** Root Mean Square Error of Approximation; **SRMR:** Standardized Root Mean Square; **TLI:** Tucker-Lewis Index.

INSTITUTIONAL REVIEW BOARD STATEMENT

The study was approved by the local research ethics committee from the University of Tabuk, Saudi Arabia (Reference number: UT-187-42-2022).

SUMMARY

MyDispense is a virtual simulation widely used by pharmacy educators; however, comprehensive clinical case validation in MyDispense exercises is lacking. This study highlighted the association between clinical case validation and student success rate. Moreover, MyDispense is helpful in validating clinical cases since all the student responses can be downloaded once as soon as the exercise is completed.

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Cite this article: Amirthalingam P, Hamdan AM, Mohamed SHP, Veeramani VP, Thangam MMN, Alanazi MF, *et al*. Association between Clinical Case Validation and Students' Success Rate in Virtual Pharmacy Simulation. Indian J of Pharmaceutical Education and Research. 2024;58(3):931-9.