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SUPPLEMENTARY WEB-BASED LEARNING PLATFORM FOR IMPROVING DIAGNOSTIC ABILITY AND CONFIDENCE IN OTOSCOPY AMONG FINAL YEAR MEDICAL UNDERGRADUATE.

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ABSTRACT

Introduction: Otoscopy is an important clinical skill to master in the undergraduate medical curriculum. This study investigated the effect of a supplementary web-based learning platform in improving diagnostic ability and confidence in otoscopy among final year medical undergraduate students. **Methods**: A supplementary otoscopy training using a web-based learning platform was provided to final year medical undergraduates who completed a three-week posting in otorhinolaryngology. A total of 45 subjects who participated in the learning platform were included in this prospective study. All of them answered questionnaires on level of confidence (LC) and diagnostic ability (DA) at three different timelines during the study: prior to intervention (T1), after intervention (T2) and 4 months following the intervention (T3). **Results**: LC and DA scores were significantly higher across the timelines measured: T1 vs T2 vs T3 respectively ($p<0.05$). Both LC and DA scores showed sustained improvements at 4 months post intervention across both external auditory canal and tympanic membrane anatomical subsites. **Conclusion**: We concluded that supplementary otoscopy training using a web-based learning platform complements the teaching and learning of otoscopy among final year medical undergraduates and is a useful teaching aid in the current pandemic.

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ABSTRACT

Introduction: Otoscopy is an important clinical skill to master in the undergraduate medical curriculum. This study investigated the effect of a supplementary web-based learning platform in improving diagnostic ability and confidence in otoscopy among final year medical undergraduate students. **Methods**: A supplementary otoscopy training using a web-based learning platform was provided to final year medical undergraduates who completed a three-week posting in otorhinolaryngology. A total of 45 subjects who participated in the learning platform were included in this prospective study. All of them answered questionnaires on level of confidence (LC) and diagnostic ability (DA) at three different timelines during the study: prior to intervention (T1), after intervention (T2) and 4 months following the intervention (T3). **Results**: LC and DA scores were significantly higher across the timelines measured: T1 vs T2 vs T3 respectively ($p<0.05$). Both LC and DA scores showed sustained improvements at 4 months post intervention across both external auditory canal and tympanic membrane anatomical subsites. **Conclusion**: We concluded that supplementary otoscopy training using a web-based learning platform complements the teaching and learning of otoscopy among final year medical undergraduates and is a useful teaching aid in the current pandemic.

Keywords: Anatomy, Clinical skill, Ear, Physical examination, Teaching, Web-based intervention.

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INTRODUCTION

Otoscopic examination is a difficult skill to master during both the undergraduate and postgraduate levels. Therefore, the diagnostic accuracy of a medical practitioner in common otologic conditions remains questionable. A

systematic review among paediatricians from the United States revealed a low diagnostic accuracy in acute otitis media, although it is a common otologic disease.[1] Teaching and learning of otoscopic examination are often inadequate at both the undergraduate and postgraduate levels. As a result, the diagnostic accuracy of a healthcare practitioner, in diagnosing common otologic conditions remains questionable. In a systematic review of the literature from 1996 to 2003 by Blomgren et al, the diagnostic accuracy of acute otitis media ranged between 38% to 50% among pediatricians from various states in the United States.[1] Although similar studies have not been carried out in South East Asia, we feel that this problem is rampant in our current setting. Failure to accurately diagnose this condition will result in over or under diagnosis leading to improper treatment, development of complications, and promotion of antimicrobial resistance.[1]

In our current undergraduate medical curriculum, otoscopy training was provided in a three-week posting in the otorhinolaryngology department, which takes place in the fourth undergraduate year. During this posting, students listen to lectures on otologic conditions in a large group, receive one-hour face to face training in a small group of 6-8 students and later directly observe patient experiences in the clinic ward. The authors observed that, continued teaching and learning of otoscopy examination was negligible outside this formal, three week posting. This lack of directed independent learning may contribute to reduced confidence and proficiency in otoscopy examination as the student progresses to the final, fifth year of the program.

In this study, we sought to develop a web-based learning platform to provide supplementary otoscopy training to the final year undergraduate medical students. This learning platform includes educational resources on otologic diseases, instructional videos and a discussion forum to enhance learning of otoscopic examination. The purpose of the study is to investigate the students' level of confidence and diagnostic ability in otoscopy at baseline, directly after and four months after using the supplementary web-based learning platform.

METHODS

A prospective interventional study was conducted among final year medical undergraduates from a single public university in Malaysia between January 2019 and August 2019. Participation in the study was voluntary and written informed consent was obtained from each subject. The sample size needed to exclude the null hypothesis calculated from the previous study by Fisher and Pfleiderer (1992) yielded 31 subjects to obtain a study power of 80%.[2]

All one hundred and twenty-two final year medical undergraduate students consented to the study. Subjects that did not complete any of the outcome measures were excluded from the study. A total of 77 subjects were excluded due to incomplete data, making the final study population of 45 subjects. Out of the 77 subjects who were excluded from the study, 12 subjects were unable to complete the learning materials within the study duration, 30 subjects were lost to follow-up at T2 and the remainder 35 subjects were lost to follow-up at T3. All the excluded subjects were individually interviewed via a phone call to identify the potential factors contributing to their poor compliance to the study. Audio recording of these interviews were anonymised and analysed using thematic analysis. The main reason was personal reason including inadequate time (70.84%) and did not notice reminders (29.16%). All excluded subjects agreed that the materials provided were accessible, easy to navigate and they continued to use the learning plat-

form despite being excluded.

Development a web-based learning platform on otoscopic examination

A web-based learning platform was developed using an online account on the Schoology™ (Schoology Inc., New York) platform, available online at: https://app.schoology.com/course/1993729423/materials. A unique access code was given to all the study subjects to ensure selective enrolment to the online course. The learning materials included lecture notes and instructional videos on otologic diseases, audiological tests, and otoscopic examination developed within the study. All otoscopic images and videos were captured using Horus Digital Otoscope ® (Miis, Taiwan) to simulate real-life experiences with the traditional hand-held otoscope. This study was approved by the Institutional Ethical Review Board of Universiti Kebangsaan Malaysia Medical Centre (FF-2019-324) along with the research support grant on 28th of June 2019.

Intervention

All subjects in the study underwent the same intervention: online learning through materials provided within the course. Subject logs were monitored throughout the study duration to ensure that all materials provided were viewed, at least once. An online discussion forum was available to answer questions from the subjects. All questions posted were answered within 24 hours by an experienced otorhinolaryngologist.

Study Outcome Measures

The study utilised self-administered, online questionnaires to assess the level of confidence in the otoscopic examination and single best answer questions on diseases of the ear canal and tympanic membrane to test the diagnostic ability. These questionnaires were delivered online, time-bound relative to the time when the subjects first complete all the learning materials provided.

The study subjects were instructed to complete all the questionnaires at three different timelines during the study: prior intervention (T1), after the intervention (T2) and four months following the intervention (T3). Reminders were sent through text messages via WhatsApp Messenger™ (WhatsApp Inc.,California) and Schoology™ (Schoology Inc.,New York) applications.

Questionnaire Assessing the Level of Confidence

The subjects' self-perceived confidence was evaluated using a questionnaire to assess the subjects' level of confidence in the otoscopic examination at T1, T2, and T3. This study used a similar questionnaire as Kaf et al, using a Likert scale of 1-5, low to high at six different variables pertaining to the external auditory canal and tympanic membrane.[3]

Questions Assessing Diagnostic Ability

To measure subjects' diagnostic ability in common ear pathologies, 25 one best answer questions on common diseases of the ear were constructed. The questions underwent rigorous content validation by an expert panel, which consisted of one otology consultant (clinical experience > 15 years) and three otorhinolaryngologists (clinical experience >5 years). The validated questions included six questions on diseases of the external auditory canal and 19 questions on diseases of the tympanic membrane. Each correct answer was given one mark and each wrong answer was given zero marks.

Statistical Analysis

Descriptive statistical analysis on the demographic characteristics; gender, ethnic, and age were analysed by using percentage and frequency. Continuous data; the level of confidence and diagnostic ability were analysed by comparing means and standard deviation between the three different timelines: prior intervention (T1), after the intervention (T2) and four months following the intervention

(T3). One-way ANOVA test with confidence interval 95% was used to compare means between 3 set of data: prior intervention (T1), after intervention (T2), and four months following the intervention (T3). The two study parameters were analysed respectively across the time of sampling and also according to ear anatomical sites (external auditory canal and tympanic membrane). A p-value of ≤0.05 was considered to be significant in tw o-tailed tests. All of the analysis was conducted using SPSS version 23.0 (SPSS Inc., Chicago, IL).

Table I: Demographic characteristics of study population.

Demographic characteristics	n(%)	*P* values
Gender		
Male	19 (42.2)	0148
Female	26 (57.8)	
Ethnicity		
Malay	30 (66.7)	
Chinese	11 (24.4)	***<0.001****
Indian	2 (4.4)	
Others	2 (4.4)	
Age		
24 years	31 (68.9)	
25 years	13 (28.9)	***<0.001****
26 years	1 (2.2)	

**p-value* using Chi-Square test for independence.

RESULTS

Demographic Characteristics

One-hundred and twenty-two final year medical undergraduate students participated in this prospective interventional study. A total of 45 out of 122 (36.9%) subjects completed all the study variables prior to intervention (T1), directly after the intervention (T2) and four months following the intervention (T3), and were recruited for this study. Of the 45 subjects recruited, equal proportions were males (19 subjects (42.2%)) and females (26 subjects (57.8%)) with a p-value of 0.1482. The ethnic group distribution was significantly different, where majority were Malays (66.7%), and Chinese (24.4%). Age of the subjects ranged from 24 to 26 years of age, with the majority of the subjects aged 24 years old (68.9%). [Table I]

Parameters Measured Across Time of Sampling

Level of Confidence

The levels of confidence of the subjects were assessed at three different timelines during the study: prior intervention (T1), after the intervention (T2) and four months following the intervention (T3). One-Way ANOVA test was used to compare means of total score for level of confidence between the three timelines. The mean of total scores for level of confidence showed significant improvement from T1 at 20.87 (2.920) to T2 at 24.98 (3.265) and T3 at 26.44 (3.094). A significant difference in the distribution of the mean of total scores for confidence level was demonstrated with a p-value of <0.05. [Table II]

Diagnostic Ability

The diagnostic ability of the subjects was assessed at three different timelines during the study: prior intervention (T1), after the intervention (T2) and four months following the intervention (T3). One-Way ANOVA test was used to compare means of total score for diagnostic ability between the three timelines.

Mean of total scores for diagnostic ability showed significant improvement from T1 at 15.24 (3.868) to T2 at 19.38 (3.863) and T3 at 20.44 (3.137) (p<0.05). [Table II]

Parameters Measured According to Anatomical Sites across Time of Sampling

Level of Confidence

Mean of total scores for level of confidence in the external auditory canal showed significant improvement from T1 at 7.56 (1.159) to T2 at 8.64 (1.026) and T3 at 9.09 (0.925) (p<0.05). [Table II] Mean of total scores for level of confidence in tympanic membrane

Table II: Study parameters according to ear anatomical sites (external auditory canal and tympanic membrane) across time of sampling.

Parameters measured	Characteristics	Time of Sampling	Score (Mean ± SD)	p Value
Level of confidence	Total score (30/30)	T1	20.87 ± 2.92	
		T2	24.98 ± 3.27	***<0.001****
		T3	26.44 ± 3.09	
	External auditory canal (10/10)	T1	7.56 ± 1.16	
		T2	8.64 ± 1.03	***<0.001****
		T3	9.09 ± 0.93	
	Tympanic membrane (10/10)	T1	6.98 ± 1.23	
		T2	8.33 ± 1.30	***<0.001****
		T3	8.84 ± 1.02	
Diagnostic ability	Total score (25/25)	T1	15.24 ± 3.87	
		T2	19.38 ± 3.86	***<0.001****
		T3	20.44 ± 3.14	
	External auditory canal (6/6)	T1	4.38 ± 1.03	
		T2	5.29 ± 0.82	***<0.001****
		T3	5.20 ± 0.87	
	Tympanic membrane (19/19)	T1	10.91 ± 3.34	
		T2	14.07 ± 3.48	***<0.001****
		T3	15.20 ± 2.81	

*Analysis performed using One-Way ANOVA.

showed significant improvement from T1 at 6.98 (1.234) to T2 at 8.33 (1.297) and T3 at 8.84 (1.021) ($p<0.05$). [Table II]

Diagnostic Ability

Mean of total scores for diagnostic ability in external auditory canal showed significant improvement from T1 at 4.38 (1.029) to T2 at 5.29 (0.815) and T3 at 5.20 (0.869) ($p<0.05$). [Table II] Mean of total scores for diagnostic ability in tympanic membrane showed significant improvement from T1 at 10.91 (3.336) to T2 at 14.07 (3.480) to T3 at 15.20 (2.809) ($p<0.05$). [Table II]

DISCUSSION

A supplementary web-based learning platform for the medical undergraduates of Universiti Kebangsaan Malaysia was developed within this study. This platform was created to tailor to the needs of the current curriculum of the university as well as the local setting. We refrained from using a web-based learning platform developed by the Western countries as it may possess striking disadvantages including cost and lack of linguistic and cultural adaptations unique to the learner and their future patients.[4] This study demonstrated long term beneficial effects on students' level of confidence and diagnostic ability which was not demonstrated in previously published interventions in teaching and learning of the otoscopic examination.[4, 5]

The present study demonstrated a significant increment in the subjects' perceived level of confidence in performing otoscopy. The improved confidence level is sustained at even four months following the study intervention. This shows that a web-based learning platform may be an effective supplement to teaching and learning of otoscopic examination. Other interventions described included small group teaching, simulator and supplementary training.[3, 5, 6]

The final year medical undergraduate students were less confident in the identification and discerning abnormalities of the tympanic membrane compared to the external auditory canal. The mean total score in identification and detecting an abnormality in the tympanic membrane was lower compared to the external auditory canal across the different timelines of the study. In a study by You et al, similar finding was observed and the deeper, inaccessible location of the tympanic membrane was postulated as its contributing factor.[5]

A significant short-term improvement in diagnostic ability scores was demonstrated in the present study and other interventions using validated questions on ear diseases.[3, 4, 7] However, our findings confirm that similar to the level of confidence, the diagnostic ability scores were sustained at high scores over a period of four months. The results obtained were echoed by another study by Dastjerdi et al, which showed improved retention at 3 months in a different study population learning empirical science using a multimedia program.[8]

We postulate that the sustained improvements seen in the present study can be partly explained by the Kolb model of experiential learning and the social constructivist theory.[9, 10] Lectures and small group training during the formal posting has been shown to provide a solid learning experience in otoscopy examination.[11] Although patient experiences and case scenarios encountered during and outside of the formal posting may allow reflection, problem solving and decision making based on prior learning experiences, the lack of discussion and feedback mechanism may deter learners from progressing on the experience ladder.[11, 12] In this study, discussion and feedback were provided in written forms using the online discussion forum. The discussion forum is made public and readily available, which can be more effective for the student. Providing feedback in a timely, and almost immediate manner, has been shown to provide reassurance and confirm progress among students. [12]

In this new era of social distancing, rapid progression in multimedia technology has allowed the use of web-based platforms for teaching and learning. Studies conducted even prior to the pandemic has shown that web-based learning can offer many potential advantages over the traditional method of learning.[13] Its strong points include utilization of graphic images, sound and video, interactive learning by quiz or feedback, and ability to revisit the content for revision. Additionally, web-based teaching is low-cost, and is widely accessible.[14] Grundman et al. concluded that the integration of visual and audio contents using web-based learning was able to improve students' examination skills and diagnostic ability compared to revising printed lecture notes.[13] Web-based learning was proven to be successful in teaching otoscopy to undergraduate medical students in a study published in 2016 by Stepniak et al. [15]Despite its favourable outcomes, this study used an expensive platform with a very limited follow-up period of only one week. In our study, the long-term effectiveness of learning otoscopy through a newly developed web based platform is highlighted.

This study helps to demystify the role of this adjunct method in otoscopy training. This skill is important to master before they graduate especially as they are preparing themselves to diagnose otologic conditions and manage these diseases independently in general practice. Inadequate mastery of the otoscopic examination will contribute towards misdiagnosis, antimicrobial resistance and even morbid complications among future patients. It is appealing to the general practice as a significant proportion of patient presents with ear complain, the most prevalent being, otitis media with effusion which is reported to

be as high as 18.3% among pre-schoolers.[16] In the light of the coronavirus pandemic where distant learning is becoming the norm, this paper provides more evidence on the effectiveness of using a web-based learning platform as an adjunct to clinical teaching in medical education practices.

We acknowledge the high rate of dropouts in this present study. Despite this limitation, this study managed to achieve the targeted sample size to obtain a considerably good study power of 80%. Having a control group without intervention to compare the study outcome measures would improve future study designs.

CONCLUSION

A web-based learning platform for otoscopy is an effective tool that complements the teaching and learning of otoscopy among final year medical undergraduates. There are sustained improvements at 4 months in the level of confidence in performing otoscopy and diagnostic ability among the subjects following this intervention. This accessible and mobile learning platform may be a valuable addition to the undergraduate medical curriculum.

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DECLARATIONS

Ethics approval and consent to participate: The study was approved by the institutional ethical review board for human research of University Kebangsaan Malaysia within which the study was undertaken (IRB code of approval: FF-2019-324). All study participants provided a written consent to participate in the study. Participation is voluntary and all students who fulfilled the inclusion criteria were invited to participate.

Availability of data and material: The dataset supporting the conclusions of this article is available in the corresponding author's repository at https://docs.google.com/spreadsheets/d/1qWoryXTjRENSEpRLM6PKy5YoaZblasrp3eTuBdzEUos/edit?usp=sharing. Link to the dataset will be activated following a formal request made to the corresponding author after the manuscript has been published for duration of five years to protect the confidentiality of the research participants, according to the institutional requirements.

COMPETING INTERESTS

All authors do not have any competing interests to declare.

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