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Research Article

Online Learning Resources Enhanced Teaching and Learning of Medical Mycology among Medical Students in Gulu University, Uganda

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Background. The burden of serious fungal diseases has significantly increased in the past few decades; however, the number of health-care workers with expertise in the management of fungal diseases remains low, especially in low- and middle-income countries (LMICs). This study aimed to evaluate the use of freely available online teaching material to enhance teaching and learning of medical mycology among medical students in Gulu University Medical School, Uganda. *Methods*. We conducted a cross-sectional study among second year medical students undertaking Medical Mycology course on antifungal agents in the department of Medical Microbiology and Immunology in the academic year 2017-2018. The materials were synthesized and peer-reviewed by experts in fungal diseases and were made freely available on the Leading International Fungal Education website (http://www.LIFE-Worldwide.org). A local faculty in the department delivered the lectures, and pre- and posttest scores were evaluated statistically. *Results*. Sixty medical students participated in the study of which 78% were male. The average score was 41% for the pretest and 52% for the posttest ($p < 0.0001$). There was no significant difference in the scores of males and females. Majority of the students gave an above-average rating for the course material; however, 54% preferred prerecorded videos. *Conclusion*. Using freely available online materials on medical mycology can enhance teaching and learning of medical mycology. Because of this, there is need to incorporate up-to-date information about the subject into the curriculums of medical schools especially in LMICs.

1. Introduction

Serious fungal diseases, occurring as a consequence of comorbid medical conditions including human immunodeficiency viruses (HIV), chronic respiratory diseases (e.g., asthma, pulmonary tuberculosis, and chronic obstructive pulmonary disease), primary immunodeficiency, and other non-HIV immunocompromising states, such as cancers, solid-organ, and hematopoietic stem cell transplantation and long-term corticosteroid administration, kill more than 1.5 million people and affect over a billion people yearly [1, 2]. Mortality due to serious fungal diseases is comparable to that of tuberculosis (~1.7 million deaths) and more than that due to malaria (~0.5 million deaths annually) [3]. Though most deaths from fungal diseases are avoidable, public health authorities still neglect addressing the challenge posed by fungal diseases [4].

Low- and middle-income countries (LMICs) are disproportionately affected by serious fungal diseases due to factors such as high burden of HIV/AIDS, limited access to

health services, limited availability, poor infection control practices, and access to antifungal medications. In addition, there is insufficient knowledge on the prevention, diagnosis, and treatment of serious fungal infections amongst health workers [5]. Fungal infections are common in Uganda [6]. It is estimated that about 2.5 million (6.5%) Ugandans suffer from at least one or more fungal infections every year [6]. People living with HIV are particularly at risk of opportunistic fungal infections. There are approximately 800 HIV-positive adults with *Pneumocystis jirovecii* pneumonia (PJP) annually and up to 42,000 children with PJP per year. There are an estimated 4,000 to 5,000 cases of cryptococcal diseases annually. Cryptococcosis and PJP cause around 28,000 deaths in adults and children every year in Uganda [6].

Early accurate diagnosis and early initiation of an appropriate antifungal agent is associated with better outcomes in serious fungal disease [7]. With the huge burden of opportunistic fungal infections and the dire need for expertise in the diagnosis, treatment, and prevention of these diseases in Uganda, it is prudent that the prevailing and future clinicians (clinicians in training) are equipped with an up-to-date knowledge on the management of these challenging and potentially life-threatening infections.

We hypothesized that delivering up-to-date educational materials, freely available for download online, on the diagnosis, treatment, and prevention of fungal diseases to heath workers (including those in training) in LMICs would increase knowledge and awareness on the prevention, diagnosis, and treatment of serious fungal infections so as to improve outcomes of patients with these devastating infections.

In this study, we aimed to evaluate the use of freely available online teaching material to enhance teaching and learning of medical mycology among medical students with three main objectives: (1) to provide up-to-date educational materials on antifungal therapy to medical students; (2) to assess the knowledge and awareness of medical students on the use of antifungal agents; and (3) to evaluate the quality, suitability, and mode of delivery of the educational materials for medical students.

2. Methods

2.1. Study Setting and Participants. We conducted a cross-sectional pilot study at the Department of Medical Microbiology and Immunology at Gulu University Medical School, Gulu, Uganda. Second year students pursuing a Bachelor of Medicine and Bachelor of Surgery (MB ChB) constituted the study population. The study was scheduled during the recess term of second year of the MB ChB course in the academic year 2017/2018 to coincide with the time the students were taking medical mycology as a course unit alongside with medical virology.

2.2. Study Materials. Educational materials on the five antifungal agents listed on the World Health Organisation (WHO) Essential List of Medicines [8], i.e., amphotericin B, flucytosine, fluconazole, itraconazole, and voriconazole were synthesised by experts in clinical mycology (FB & Professor David W. Denning). Emphasis was put particularly on the pharmacokinetic and pharmacodynamic profiles of these antifungal agents, their common clinical indications, contraindications, and common adverse events of clinical significance, consistent with the medical school curriculum. Data included in the educational materials were drawn from multiple sources, including peer-reviewed journal articles, the British National Formulary, WHO and infectious diseases/mycology society disease-specific guidelines, and medical textbooks. The materials were peer-reviewed by experts and were made freely available on the Leading International Fungal Education (LIFE) website in various formats including PowerPoint slide sets, video, and podcast at http://life-worldwide.org/life-education-slide-sets-video-presentations-and-reading-materials.

2.3. Lecture and Assessment. An experienced clinical microbiologist (EB) who is a faculty member of the department delivered all the five lectures, with each antifungal agent constituting a lecture in a separate set of PowerPoint slides. Lectures were delivered over a 2-day period. Day 1; amphotericin B and flucytosine and Day 2; the triazoles (fluconazole, itraconazole, and voriconazole).

Twenty-five pretested questions, examining the different pharmacological aspects of the five antifungal agents administered to students before lectures constituted the pretest. The participants were given 20 seconds for each question and rewarded four points for each correct answer, with a total score of 100 points. The same questions were administered immediately after lectures to obtain posttest results.

2.4. Course Evaluation. A one-page course evaluation formed was administered after the posttest examination. Students were asked to rate the presentation on a scale of 1 (poor/low) to 5 (excellent/high) in the following categories: (1) the clarity of the objective of each lecture ("objective"), (2) the relevance of the contents ("content"), (3) the clarity of the presentation ("clarity"), (4) the relevance of the topics to their learning ("relevance"), (5) whether the knowledge would help them in the proceeding clinical years ("knowledge"), (6) gain a better understanding of antifungal therapy after the lecture ("understanding"), and (7) if they would recommend this course to future students ("recommend").

2.5. Statistics. All statistical analyses were performed using GraphPad prism v8.0.1 software (GraphPad Software Inc., La Jolla CA, USA). The Shapiro–Wilk normality test was used to assess the distribution of the pretest and posttest examination scores. The difference between the male and female students in pre- and posttest examinations was analyzed using independent sample t-tests. The Wilcoxon matched-pairs signed rank test or paired sample t-test was used as appropriate to compare pre- and posttest performances. The mean or median difference in performances

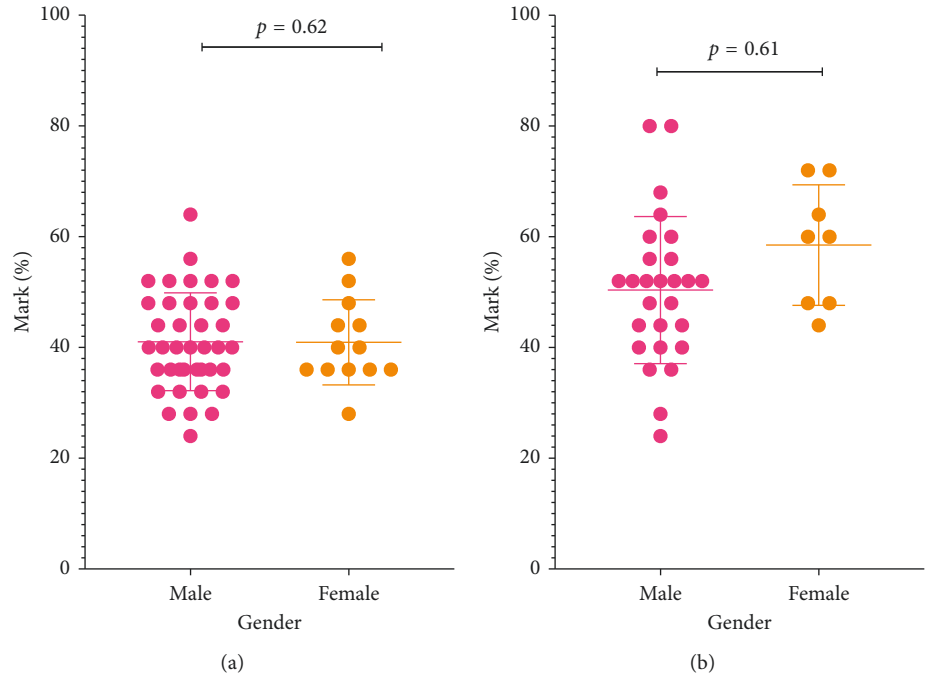

FIGURE 1: **Examination scores**. (a) Pretest and (b) posttest scores of the medical students stratified by gender.

was considered significant at $p < 0.05$. All of the p values were two-tailed.

2.6. Ethics. This was a quality improvement project at the department of Medical Microbiology & Immunology of Gulu University Medical School. All students provided informed consent to participate in the study, and marks scored in this study were not used for progressive or summative assessment of the course.

3. Results

In total, 78% (60 of the 77) of the students participated in the study. Majority of the students were males (78%, $n = 47$). Fifty-two (87%) students sat for the pretest examination, thirty-nine (75%) of whom were males. Meanwhile, only 35 (58%) students sat for the posttest examination. Twenty-seven (45%) sat for both pretest and posttest examinations.

3.1. Pretest Examination. The mean mark scored was 41% (±SD = 8.5, $n = 52$). There was no significant difference in the performances of both sexes, i.e., male (mean, SD: 41 ± 9; $n = 39$) vs. female (mean, SD: 41 ± 9; $n = 13$), $p = 0.62$ (Figure 1(a)).

3.2. Posttest Examination. The average mark scored was 52% (±SD = 13, $n = 35$). The mean score of males was 50% (SD ± 13, $n = 27$), and for females, it was 59 (SD ± 11, $n = 8$). However, the difference in the performance between male and female students was not statistically significant ($p = 0.61$) (Figure 1(b)).

3.3. Prepost Matched Results. There were 27 matched pre- and posttest results with higher scores in the posttest. The mean of the difference of pretest and posttest examination performances was 14.4% (95% confidence interval: 9.2–19.6; $p < 0.0001$). Twenty-three students improved their scores, some dramatically, and four did not Figure 2.

3.4. Course Evaluation. Thirty-five students completed the course evaluation form. Overall, 13 (37%) students rated the slide sets as excellent, 20 (57%) as good, and 2 (6%) as average. All the participants agreed ($n = 17$) or strongly agreed ($n = 18$) the content of the slides were appropriate for medical students. Nineteen (54%) students agreed ($n = 9$) or strongly agreed ($n = 10$) they would prefer prerecorded videos on the taught topics to a lecture. However, 10 (29%) students disagreed and 6 (17%) neither agreed nor disagreed with their preference for prerecorded videos or conventional lectures. The students rated the course based on the objectives, content, clarity, relevance, knowledge, understanding, and recommendation as shown in Figure 3.

4. Discussion

The results of this pilot study indicate that using freely available online up-to-date material can enhance teaching and learning of medical mycology especially in LMICs, as indicated by the significant improvement in the scores of the posttest. Medical mycology is not a new area of study in Uganda. It has always been part of the curriculum in medical schools incorporated under the microbiology modules, but with a narrow scope. However, there are many recent advances in the field of medical mycology that are not yet included in the current curriculums of Ugandan Universities.

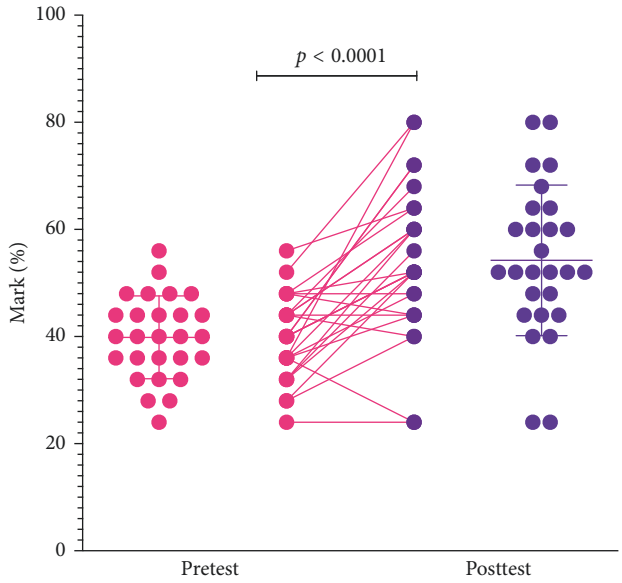

Figure 2: **Comparison of pre- and posttest:** the figure shows a scatter dot plot of performance of an individual student and matched pre- and posttest scores. There was a statistically significant improvement in the students' performance in the posttest scores.

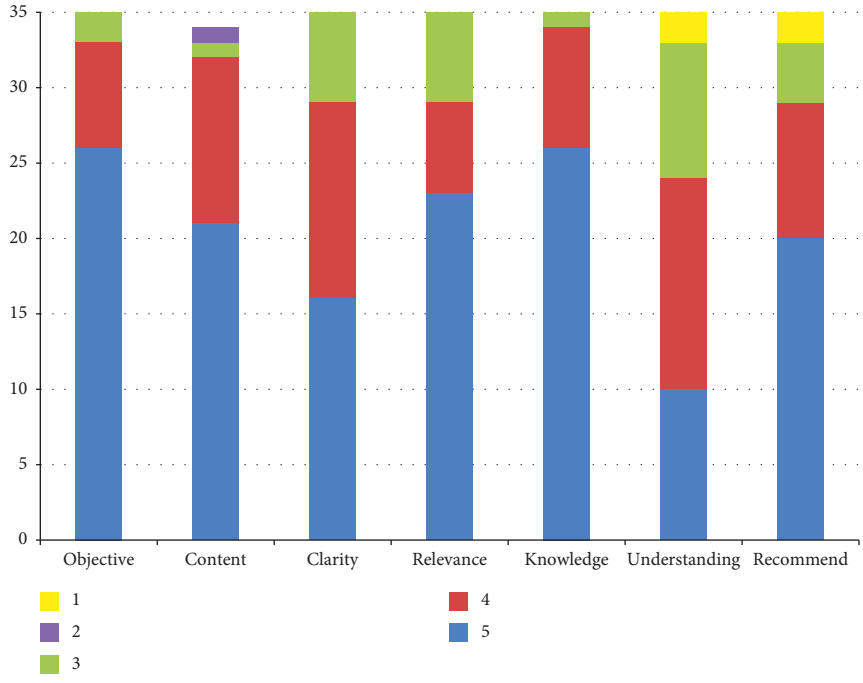

Figure 3: **Students' rating of the course.** Students rated the course based on the objectives, content, clarity, relevance, knowledge, understanding, and recommendation.

There is a clear deficiency of up-to-date information regarding the prevention, diagnosis, and treatment of fungal infections in LMICs like Uganda. These freely available online educational materials, if adopted into the current curriculums, would greatly enhance the teaching and learning of medical mycology in Uganda and other LMICs.

Besides, there are 155 hospitals in Uganda (public and private), and of these, two are National Referral Hospitals, 14 are Regional Referral Hospitals (RRHs), and 139 are General Hospitals (GHs). However, none of these has a medical mycologist. The consequences of delayed or missed diagnosis include death, increased disease transmission, disabilities, and social and economic losses. Highly qualified clinical and laboratory mycologists are needed to combat fungal diseases and advance the field. These would ideally enhance knowledge and practical expertise in the epidemiology, diagnosis, management, prevention, and research in fungal diseases in these LMICs so as reduce the burden of fungal diseases. This

can be achieved by introducing graduate training in medical mycology in these areas. The graduate training can equip the medical and laboratory cadres with a significant level of theoretical understanding and practical skills, which are important for following a career in clinical sciences or academic and industrial research.

Establishment of a functional medical mycology society in Uganda would be a great way to hasten the dissemination of mycology knowledge and skills nationwide. A recent position paper has demonstrated awareness, diagnosis, and management of serious fungal diseases in Nigeria following a recent introduction of a Medical Mycology society [9]. Furthermore, to improve patient care, the World Health Organization (WHO) is emphasizing development of Point-of-Care (POC) tests that would rapidly diagnose diseases at the initial contact at a healthcare facility, thus limiting transmission [10]. So far, most of the POC tests for fungal infections such as cryptococcal meningitis and aspergillosis have a mycological basis, and their interpretation requires a sound understanding of mycology [7, 11]. This can be achieved through advanced training in mycology as mentioned above. For resource-limited countries like Uganda, the need for training in mycology cannot be overemphasized.

5. Limitations

The main limitation of this study is the small number of students with paired results. In addition, only medical students were included as participants. It would be good to compare these medical students to laboratory students and newly qualified doctors. The results of this pilot study may not be the same for other Ugandan Universities. A multiuniversity study may produce better results. However, this is the first study to demonstrate the usefulness of online materials in medical mycology, synthesized, and reviewed by experts in the field and delivered by a local expert to the students.

6. Conclusion

In this pilot study at Gulu University Medical School, we have cross-sectionally demonstrated that using freely available online material could enhance teaching and learning of medical mycology especially in LMICs. However, there is an urgent need to incorporate up-to-date information about medical mycology into the curriculums of medical schools in LMICs. This may be enhanced by introduction of graduate training in medical mycology.

Data Availability

All relevant data were included in the manuscript. The corresponding author can be reached at for raw data.

Conflicts of Interest

FB, BE, RK, and EOA declare no conflicts of interest.

Authors' Contributions

FB conceived and designed concept/protocol. BE delivered the lectures and collected the data. FB performed data analysis. FB and RK participated in initial manuscript drafting. FB, RK, BE, and EOA participated in critical revisions for intellectual content. BE and FB participated in administrative, technical, or material support.

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