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E-learning as a strategy in dentistry in the context of COVID-19: a path to follow?

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Abstract: The current study aims to assess the effectiveness of e-learning in compliance with the new biosafety recommendations in dentistry in the context of COVID-19 applied to the clinical staff of a dental school in Brazil. A quasi-experimental epidemiological study was carried out by means of a structured, pre-tested online questionnaire, applied before and after an educational intervention, using an e-learning format. After data collection, statistical tests were performed. A total of 549 members of the clinical staff participated in the study in the two collection phases, with a return rate of 26.9%. After the e-learning stage, a reduction was found in the reported use of disposable gloves, protective goggles, and surgical masks. The course had no impact on the staff's knowledge concerning the proper sequence for donning PPE and showed 100% effectiveness regarding proper PPE doffing sequence. Knowledge about avoiding procedures that generate aerosols in the clinical setting was improved. Despite the low rate of return, it can be concluded that online intervention alone was ineffective in significantly improving learning about the new clinical biosafety guidelines. Therefore, the use of hybrid teaching and repetitive training is highly recommended.

Keywords: Dentistry; COVID-19; Education, Distance; Knowledge; Attitude.

Introduction

Even before the outbreak of COVID-19, dental education had already undergone changes in terms of teaching methods as a result of the increase in demand and limited resources, which made face-to-face learning difficult.[1] Certainly, the pandemic and the need for social distancing markedly challenged dental education, characterized mainly by face-to-face learning, especially in undergraduate courses.[2,3] The interruption of face-to-face teaching caused by the pandemic highlighted the relevance of combined (hybrid) or pure online (e-learning) teaching; however, its effectiveness is still inconclusive.[4] As face-to-face meetings were not allowed in regions with a moderate to high community transmission of SARS-CoV-2, e-learning has become a viable option for many educational institutions.[5,6] In this context, COVID-19 has accelerated the reformulation of dental education modalities.[7]

According to Chang et al.,[7] three blocks make up dental education: 1) expository/problem-based learning (PBL); 2) simulation laboratories courses; and 3) clinical skills training (internship). While the first one can be easily adapted to the online format, the same does not apply to the other modalities. Clinical activities involving close proximity among attendants, patients, and staff were the first to be suspended and adapted to the online learning format, representing one of the core challenges faced by dental schools.[6,8] Thus, impacts can be observed both in education and dental practices because of the risks involved.[3] Furthermore, there is a limit to the implementation of e-learning regarding the acquisition of clinical skills.[9]

With the need for a gradual return to dental clinical activities in educational institutions, the preparation of the entire team becomes vital so that it can be carried out safely. Dental schools must prepare everyone involved for the prevention and control of COVID-19, and online training has been a recurrent strategy for teaching these new biosafety measures.[7] The CDC[10] recommends that Dental Health Care Personnel be trained whenever new occupational exposure risks are identified, as in the emergence of COVID-19. Therefore, prior training in guidelines is essential for safety and confidence in the return and maintenance of those activities.[7,11] In this sense, online training in biosafety protocols based on the main scientific evidence about SARS-CoV-2 is extremely important to facilitate access to safe and reliable sources. However, the need for constant updates, highly rigorous biosafety practices for the prevention and control of the pandemic, as well as the restrictions currently imposed on the development of dental practices represent an unprecedented challenge to both dentistry and dental education worldwide.[12]

The dental environment has aerosol and splashes that can transmit COVID-19. Therefore, the new protocols should cover different types of knowledge such as the use of personal protective equipment (PPE), as well as other measures for the prevention and control of aerosol and splash dispersion, such as strong saliva ejectors and pre-procedural mouthrinse, among others.[13] Previous studies had already pointed out important gaps in the knowledge of these new guidelines among health professionals, indicating low levels of knowledge.[13–15] Even with the large-scale vaccination of the population, the threat posed by SARS-CoV-2 and its relevant variants encourages the maintenance of preventive measures, such as hand hygiene, the use of masks, and social distancing,[11] demonstrating the relevance of the continuity of hybrid or pure online education in adaptable activities. Nevertheless, vaccinated dental professionals may show a decrease in the use of PPE.[16] Thus, evaluating these variables is essential to identify possible weaknesses and strengths of e-learning as a learning aid strategy in dentistry.

Also, studies have shown that participants in online learning in this area may feel less satisfied with learning, have difficulty in communicating with colleagues and instructors, have minimal familiarity with the new modality, lack motivation, and lack self-discipline. Hence, its effectiveness should be studied.[6,9,11] Thus, the current study aims to assess the effectiveness of the e-learning modality concerning the new biosafety recommendations in dentistry in the context of COVID-19 in the clinical staff of a dental school.

Methodology

This was a before-and-after quasi-experimental epidemiological study conducted with the clinical staff of the Dental School of Universidade Federal de Minas Gerais (UFMG). The study population consisted of all members of the clinical staff, including one undergraduate and one graduate student, faculty members, and dental assistants. The inclusion criteria were undergraduate and graduate students, faculty members, and the dental assistant staff of the UFMG Dental School who work in dental clinics. All participants who did not answer the questionnaire within the requested period were excluded from the study.

The data collection instrument was a structured, pre-tested online questionnaire, developed from previous studies and evaluated by three independent

local experts. Thereafter, two pilot studies were carried out in the test and retest model (Cohen's kappa > 0.6). The questionnaire was divided into three blocks of questions: data demographics; compliance with different types of PPE, and the correct PPE donning and doffing sequence (nine questions); in addition to basic knowledge of the new guidelines (11 questions). For the last block, participants should answer what their level of agreement on the statements presented was, using a Likert scale for the following outcomes: indications for mouthwashes, risk classification for clinical dental care, product processing for health, cleaning, and disinfection of the work area and mold, disposal of sharp instruments, emergency dental care for patients suspected of having COVID-19, dental care by a professional suspected of having COVID-19, and aerosol-generating procedures.

The first stage of data collection was carried out before the training, from November to December 2020. During that period, no vaccination against COVID-19 was available in Brazil. From then on, the e-training on the subject was conducted through the UFMG Dental School's digital platform, with institutional login access to the Moodle platform for two consecutive weeks.

The e-learning training was prepared by the local Biosafety Committee, with a duration of 20 hours. Participation was mandatory and free of charge for all participants. The training was divided into five modules: epidemiological and clinical aspects of the COVID-19 pandemic; the environment and fixed surfaces as potential reservoirs for SARS-CoV-2; testing and monitoring of COVID-19; strategies to prevent the dissemination of COVID-19 in dental practice; and a final evaluation. Pre-test and post-test were carried out with all course participants. After the e-learning training, a new data collection was performed between December 2020 and January 2021. The collected data were computed and coded in the database using an Excel® spreadsheet, and exported for tests and analysis by the SPSS software, version 25 (IBM SPSS Statistics, Armonk, NY, USA). Univariate descriptive statistics for frequency distribution and the comparison of knowledge, attitudes, and adherence before and after the intervention were performed with the marginal homogeneity test and McNemar's test. After that, the results were analyzed. The study was submitted to and approved by the UFMG Research Ethics Committee (CAAE: 31041720.3.0000.5149).

Results

A total of 549 members of the clinical staff participated in the study in the two collection stages, before and after institutional training. The return rate was 26.9%. The mean (standard deviation) age of participants was 29.55 (11.41), ranging from 19 to 73 years. Most participants were female (73.6%).

The training reduced the reported use of disposable gloves ($p = 0.002$), protective goggles ($p < 0.001$), and surgical masks ($p < 0.001$). No other differences were identified in the use of PPE (Table 1).

Chlorhexidine gluconate showed high rates of indication as preclinical mouthwash in the two periods. However, povidone-iodine/fluoride mouthwash was the only one with a significant increase ($p = 0.039$) (Table 2).

Knowledge of the proper PPE donning sequence was similar before and after the training. The frequency of the correct PPE doffing improved from 52% in the first stage to 100% in the second stage ($p < 0.001$). A high level of agreement was found regarding the need to provide emergency dental care to patients with suspected COVID-19 ($p = 0.006$). The clinical staff improved their knowledge about avoiding aerosol-generating dental procedures ($p < 0.001$). The frequencies of all other statements remained stable (Table 3).

Discussion

This training had a limited impact on the knowledge and attitudes of the dental clinical staff members. For certain parameters, the maintenance of or decrease in the low level of knowledge was still worrisome. A positive impact was identified for the use of protective goggles and surgical masks. Knowledge

Table 1. Frequency of compliance with the use of PPE recommended in the context of the COVID-19 pandemic before and after e-learning at a dental school, Brazil, 2020.

Variable	Before e-learning	After e-learning	p-value*
	n (%)	n (%)	
Use of disposable head covering caps			
Yes	148 (100)	136 (91.9)	
No	0 (0)	0 (0)	0.001
I don't Know	0 (0)	12 (8.1)	
Use of surgical mask			
Yes	116 (78.4)	75 (50.7)	
No	28 (18.9)	61 (41.2)	< 0.001
I don't Know	4 (2.7)	12 (8.1)	
Use of N95 respirator or similar PPE			
Yes	126 (85.1)	123 (83.1)	
No	13 (8.8)	13 (8.8)	0.544
I don't Know	9 (6.1)	12 (8.1)	
Use of isolation gown			
Yes	128 (86.5)	132 (89.2)	
No	10 (6.8)	4 (2.7)	0.819
I don't Know	10 (6.8)	12 (8.1)	
Use of gloves			
Yes	144 (97.3)	133 (89.9)	
No	4 (2.7)	3 (2)	0.002
I don't Know	0 (0)	12 (8.1)	
Use of conventional protection goggles			
Yes	88 (59.5)	64 (43.2)	
No	54 (36.5)	68 (45.9)	< 0.001
I don't Know	6 (4.1)	16 (10.8)	
Use of protection goggles with solid side shields			
Yes	114 (77)	120 (81.1)	
No	27 (18.2)	14 (9.5)	0.916
I don't Know	7 (4.7)	14 (9.5)	
Use of face shield			
Yes	130 (87.8)	134 (90.5)	
No	11 (7.4)	2 (1.4)	0.912
I don't Know	7 (4.7)	12 (8.1)	

*Marginal homogeneity test.

Table 2. Assessment of knowledge and attitudes of the clinical staff at a dental school towards the use of mouthwashes recommended in the context of COVID-19 before and after e-learning, Brazil, 2020.

Mouthwash	Before e-learning	After e-learning	p-value*
	n (%)	n (%)	
Chlorhexidine gluconate			
Yes	109 (73.6)	116 (78.4)	0.381
No	39 (26.4)	32 (21.6)	
Hydrogen peroxide			
Yes	25 (16.9)	34 (23)	0.222
No	123 (83.1)	114 (77)	
Povidone-iodine			
Yes	3 (2)	11 (7.4)	0.039
No	145 (98)	137 (92.6)	
Cetylpyridinium chloride			
Yes	11 (7.4)	15 (10.1)	0.424
No	137 (92.6)	133 (89.9)	
Essential oils			
Yes	1.4 (2)	7 (4.7)	0.125
No	146 (98.6)	141 (95.3)	
Sodium fluoride			
Yes	0 (0)	6 (4.1)	0.031
No	148 (100)	142 (95.9)	
0.9% saline			
Yes	1 (0.7)	4 (2.7)	0.250
No	147 (99.3)	144 (97.3)	

*McNemar's test.

about the use of povidone-iodine and about some guidelines during the COVID-19 pandemic showed some improvement.

The recommended types of PPE for COVID-19 were hair caps, surgical masks or N95 respirators, goggles, visors, surgical gowns, and special shoes.[17] In the current study, the reported use of hair caps during clinical care had an unexpected reduction with the addition of the "I don't know" option, which was similar to the use of disposable gloves. The use of this PPE (hair cap) is recommended for

Table 3. Assessment of knowledge and attitudes towards biosafety in the context of the COVID-19 pandemic before and after e-learning at a dental school, Brazil, 2020.

Variable	Before e-learning	After e-learning	p-value
	n (%)	n (%)	
"Currently, clinical dental care presents a very high risk for SARS-CoV-2 transmission."			
Strongly agree	98 (58.4)	73 (43.2)	0.122*
Agree	48 (28.4)	61 (36.1)	
Neither agree nor disagree	4 (2.4)	8 (4.7)	
Disagree	14 (8.3)	12 (7.1)	
Strongly disagree	3 (1.8)	9 (5.3)	
I don't know	0 (0)	6 (3.6)	
"Any clinical, restorative, surgical, periodontal, and endodontic instrument must be sterilized prior to service."			
Strongly agree	147 (99.3)	144 (97.3)	1.000*
Agree	0 (0)	4 (2.7)	
Neither agree nor disagree	0 (0)	0 (0)	
Disagree	0 (0)	0 (0)	
Strongly disagree	1 (0.7)	0 (0)	
I don't know	0 (0)	0 (0)	
"The dental chair, its peripheral equipment, and fixed surfaces must be cleaned and disinfected, following the protocols approved by the institution."			
Strongly agree	147 (99.3)	148 (100)	**
Agree	1 (0.7)	0 (0)	
Neither agree nor disagree	0 (0)	0 (0)	
Disagree	0 (0)	0 (0)	
Strongly disagree	0 (0)	0 (0)	
I don't know	0 (0)	0 (0)	
"The study model or working model should always be disinfected."			
Strongly agree	140 (94.6)	140 (94.6)	0.785*
Agree	3 (2.0)	4 (2.7)	
Neither agree nor disagree	0 (0)	0 (0)	
Disagree	2 (1.4)	1 (0.7)	
Strongly disagree	0 (0)	0 (0)	
I don't know	3 (2.0)	3 (2.0)	
"Every and each disposable sharp material should always be disposed of in a specific rigid container."			
Strongly agree	146 (98.6)	148 (100)	**
Agree	0 (0)	0 (0)	
Neither agree nor disagree	0 (0)	0 (0)	
Disagree	0 (0)	0 (0)	
Strongly disagree	0 (0)	0 (0)	
I don't know	2 (1.4)	0 (0)	

Continue

Continuation

"A patient with fever, fatigue, cough, and headache may receive emergency dental care."			
Strongly agree	28 (18.9)	45 (30.4)	0.006*
Agree	32 (21.6)	35 (23.6)	
Neither agree nor disagree	5 (3.4)	6 (4.1)	
Disagree	26 (17.6)	20 (13.5)	
Strongly disagree	39 (26.4)	37 (25.0)	
I don't know	18 (12.2)	5 (3.4)	
"A professional with fever, fatigue, cough, and headache can perform dental care."			
Strongly agree	2 (1.4)	2 (1.4)	0.136*
Agree	5 (3.4)	8 (5.4)	
Neither agree nor disagree	0 (0)	0 (0)	
Disagree	6 (4.1)	0 (0)	
Strongly disagree	135 (91.2)	138 (93.2)	
I don't know	0 (0)	0 (0)	
"Aerosol-generating dental procedures should be avoided."			
Strongly agree	62 (41.9)	123 (83.1)	< 0.001*
Agree	59 (39.9)	17 (11.5)	
Neither agree nor disagree	7 (4.7)	4 (2.7)	
Disagree	12 (8.1)	4 (2.7)	
Strongly disagree	6 (4.1)	0 (0)	
I don't know	2 (1.4)	0 (0)	
Recommended PPE donning sequence			
Correct	116 (78.4)	117 (79.1)	1.000***
Incorrect	32 (21.6)	31 (20.9)	
Recommended PPE doffing sequence			
Correct	77 (52.0)	148 (100)	< 0.001***
Incorrect	96 (48.0)	0 (0)	

*Marginal homogeneity test; **Statistical test was not performed; ***McNemar's test.

health professionals during aerosol-generating procedures.[5] However, the e-learning course addressed this differentiation between the need or not to use this PPE in accordance with the type of procedure and the presence or not of engineering control, but with the exception that in the environment of the dental school under study, the use would be adopted during all clinical care because of the local reality, which may have led to confusion among the participants. Note that these types of procedures are frequent in dental care, and the use of a cap is recommended during clinical practice.[17]

Participants reported less adherence to the use of surgical masks and conventional eye protection shields, and an increase in the use of eye protection with solid side shields and face shields after the training. As for the use of N95 respirators, there were no significant changes, with a slight reduction in the "yes" option. The study participants treated patients in a city with moderate to substantial transmission of COVID-19 in the community and worked in collective dental clinics. Hence, the recommendation for the use of N95 respirators during clinical care and in the clinical setting is mandatory.[5] The online training focused on these issues and the reduction

in the use of surgical masks could be explained by these facts.

The CDC[5] also recommends wearing eye protection with solid side shields for additional protection from aerosols generated during care, which has been improved in survey data comparisons before and after the course. The concomitant use of face shields to protect against the projection of fluids on the attendant's face and mask is also recommended,[5] which was also improved after the course, but was not statistically significant.

Another worrying fact was the reduction in the use of gloves during clinical care, as the use of this PPE has been recommended to dental professionals since the late 1980s as universal precautions and subsequent standard precautions for all patients.[18] The concern during the pandemic has not been with wearing or failing to wear gloves, as there is a consensus on that. The major concern is with their removal when doffing PPEs.[19] Nevertheless, a previous study with Brazilian dentists has shown low adherence to PPE, and, as for gloves, the argument given for non-adherence was that the equipment makes dental care difficult,[20] but with the advent of COVID-19, it became more evident that all recommended PPE is essential for breaking the chain of transmission.[16] Another possible explanation for this unusual finding could be the perception that surgical gloves could be a better option compared to conventional gloves.

Studies carried out by Suppan et al.[15,21] evaluated the impact of telemedicine on the correct donning and doffing of PPE. In the first randomized clinical trial,[21] the e-learning module did not improve the choice of PPE when compared to accessing only the summarized version of the new recommendations, which was hypothesized to be due to the high level of knowledge of the participants before the intervention. In a second study[15] conducted with paramedic students, in which knowledge was estimated to be lower, the selection of PPE was better in both groups (intervention and control), but no statistically significant differences were found. Moreover, of all the participants, only seven knew the correct PPE donning sequence after the intervention, while none of them could describe the correct PPE doffing, showing improvement only in the choice of this equipment, but not in a statistically significant manner.[15] As no post-intervention recall was used, it was suggested that only right-to-the-point interventions were not enough to improve the level of knowledge on the subject, which corroborates the findings of the current study. In the current research, the participants maintained similar success rates concerning the recommended PPE donning sequence, not exceeding 80%. As for the proper PPE doffing sequence, statistically significant improvement from 52% to 100% was observed in the second phase of data collection. This finding corroborates that proper video instruction about the use of PPE, used by e-learning, can improve skills.[19] Previous research has shown similar levels of knowledge for PPE doffing and higher levels for donning, where 91.6% of the participants demonstrated complete knowledge when compared to this post-intervention study (79.1% of correct answers for donning and 100% for doffing). However, 31.6% of the professionals in the other study were unaware of the higher risk during PPE removal and 49.7% considered that rigid donning/doffing practices cannot be maintained for a long time.[22] The use of a protocol, such as the CDC for the doffing of PPE, can reduce the risk of contamination when compared to any type of standardization.[19]

An impact that cannot be overlooked in the attitudes of the clinical staff is the effect of vaccination on the use of PPE. Studies have shown that the use of PPE has been decreasing after vaccination. Karayürek et al.[16] pointed out that the average amount of PPE use by unvaccinated dental participants was 4.6 and dropped to 4.3 after vaccination. The lower frequency of use of the N95 respirator after vaccination, when compared to the use of surgical masks, is also noteworthy. But the authors reinforced the importance of maintaining the use of PPE recommended for the prevention and control of COVID-19, regardless of the vaccination status of the patient and dentist.[16]

Dental aerosols have played a key role in the current pandemic and are often the focus of prevention and control measures in dental environments. Transmission through aerosols is more strongly evidenced when it occurs through procedures that

generate these smaller particles in suspension, combined with fluids from the oral cavity (blood and saliva).[17,23,24] With the emergence of COVID-19, aerosol control in the dental environment has become crucial. In this study, advances were obtained in post-training knowledge regarding the need to avoid procedures that generate bioaerosols during clinical care. In the study by Duruk et al.,[13] 49.9% would avoid performing aerosol-generating procedures as much as possible, a percentage closer to that found in the current study before the educational intervention. In another study, approximately 92% of the participants were aware of transmission through direct contact with aerosols, but no investigation was conducted as to whether respondents indicated the avoidance of procedures that generate these particles.[25]

In the current study, the indication by the participants of the different types of pre-procedural mouthwashes (PPMR) showed statistical differences only for the povidone-iodine mouthwash (PVP-I), with an increase in the indication for its use. However, the choice for chlorhexidine gluconate (CHX), followed by hydrogen peroxide (HP), prevailed at both times of data collection, demonstrating little change in the choice of mouthwashes after the training. In the study by Duruk et al.,[13] 36.4% of the dentists used 0.2 PVP-I and 10.3% CHX. A review based on scientific evidence[26] from *in vitro* and clinical studies presented the results for the virucidal effect of the main types of PPMR against SARS-CoV-2 infection. The authors point out that, despite limited evidence, beneficial effects of mouthwashes are suggested with an exposure of 30 s at 0.5-1% PVP-I or 0.04-0.075% cetylpyridinium chloride (CPC). Vergara-Buenaventura and Castro-Ruiz[27] note the need for large-scale clinical studies, as well as control studies, to measure the effectiveness of these mouthwashes. Likewise, the CDC[5] emphasizes that there is still no robust evidence on the effectiveness of PPMRs, but that CHX mouthwashes, essential oils, PVP-I, or CPC, commonly used in dental practice, may have an antimicrobial effect. The variety of information sources, in addition to those provided by the training, and the lack of consensus among the protocols may have led participants to be uncertain about the indication for use.

Statistically significant differences were obtained, demonstrating improvement in the level of post-training knowledge about urgent dental treatment of patients with suspected COVID-19. In the study by Arora et al.,[14] almost 42% of the participants were willing to care for patients with dental urgency and who were suspected of having COVID-19, as opposed to another study in which 82.6% of the respondents would choose to avoid clinical care for these patients.[28] However, it is important to note that this percentage was reported in a period in which vaccines against COVID-19 were unavailable worldwide, as well as during the data collection period of the current study, when no vaccines were available in Brazil. A more recent study[16] has observed that Turkish dental professionals had a 35.6% reduction in reported fear and anxiety post-vaccination, while the percentage of dentists reporting these psychological reactions was 76% before vaccination. This reduction in post-vaccination psychological reactions may lead to different results from those found in our study.

Online educational interventions have been applied by many higher education institutions. These interventions became essential with the emergence of COVID-19 and the subsequent interruption/reduction of face-to-face activities in several institutions and dental clinics around the world.[7,15,29] As shown, the e-learning course had some limitations in terms of reaching the expected level of learning. Although e-learning is rated as satisfactory by some studies,[30–32] Abbasi et al.[33] emphasize that, for students in the health area, the acquisition of technical and clinical skills may not be effective. One study[34] on the perception and performance of dental students in this modality, conducted with a sample of more than 1,000 participants, showed that 42.6% considered their performance on the platform poor or terrible, preferring face-to-face activities. The authors emphasize, however, that the psychological impact of the pandemic, such as fear and anxiety, which can influence the negative perception of e-learning, and the affective aspect of the presence of the professor and colleagues, should not be disregarded. In another study on the perception of students in dental education, more than

75% rated e-learning as highly credible.[35] One of the challenges for the success of e-learning can be the access to technology, such as internet connectivity, as well as the infrastructure to implement this system and the users' own motivation.[36,37] Another complicating factor is to what extent the response rate to surveys with data collection through online platforms can be lower when compared to collections made manually.[33,38] This was a limitation of the present study, which obtained a low response rate from the target population, thereby hindering the extrapolation of the analysis to a broader context.

Online learning can be improved through tutorials with professors in order to identify and fill gaps in students' knowledge.[33] In a course on infection control protocols like the one evaluated herein, the absence of learning repetitions can compromise learning effectiveness and leave important gaps, such as those observed in the present study. Repetitive training can be an alternative for long-term memory formation,[39,40] especially when using virtual learning as compared to only one single training without learning repetitions.

Conclusions

Notwithstanding the limitations of this study, it can be concluded that one single pure online training was not effective for high-level learning regarding the new biosafety protocols in dentistry in the context of COVID-19. However, there is no doubt that online teaching can be a valuable tool that should be incorporated into traditional methodologies. Repetition learning, as well as hybrid teaching, are possible alternatives for the use of this teaching instrument, which has been increasingly common in educational processes.

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