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ORIGINAL RESEARCH

Comparison of Compliance with Infection Control Practices Among Dental Students in Saudi Arabia Before and During the COVID-19 Pandemic

Dalia E Meisha

Department of Dental Public Health, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia

Background: With the emergence of the COVID-19 pandemic, professional organizations issued new guidelines for infection control standards in dental clinics. The objective of this study was to compare dental students' compliance with those standards before the COVID-19 outbreak and during the pandemic.

Methods: This cross-sectional study entailed observing 622 dental students during their clinical sessions to assess compliance with the infection control protocol. The compliance checklist used was adopted from the Centers for Disease Control and Prevention Infection Control Checklist for Dental Settings. Observations took place during two consecutive years: once in 2019 before the COVID-19 outbreak and once in 2020 during the pandemic.

Results: The dental students audited in 2019 were 1.4 times more likely to violate infection control measures compared with those in 2020. The two most common violations in both audits were not wearing eye protection and not following hand hygiene recommendations immediately after they removed their gloves. During both audits, male students violated infection controls significantly less often than female students.

Conclusion: Dental students' adherence to infection control measures improved during the COVID-19 pandemic compared with before the COVID-19 pandemic. Compliance with personal protective equipment standards was higher than with hand hygiene practices. Our findings have important clinical implications in designing strategies to improve dental students' compliance with infection control standards, particularly hand hygiene practices.

Keywords: COVID-19, dental infection control, dental students, hand hygiene, personal protective equipment, Saudi Arabia

Introduction

The dental profession has always been attentive to infection control practices because of the risk of cross-contamination between patients and dental health care personnel (DHCP). Infection control guidelines in dentistry are based upon the assumption that each dental patient must be considered potentially infectious.[1,2] This assumption took on new urgency with the emergence of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), also known as coronavirus disease 2019 (COVID-19)[3] when the World Health Organization declared " … the outbreak as a public health emergency" on January 30, 2020.[4] As of 19 April 2021, there have been more than 140 million confirmed cases of

Correspondence: Dalia E Meisha
Department of Dental Public Health, Faculty of Dentistry, King Abdulaziz University, P.O.Box 80209, Jeddah, 21589, Saudi Arabia
Tel +966 12-640-0000 ext. 18488
Email dmeisha@kau.edu.sa

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COVID-19 worldwide, with 776,505 newly reported cases in the previous 24 hours. Efforts to control COVID-19 are still ongoing, including the administration of approximately 800 million vaccine doses.[5] During the COVID-19 pandemic, virus transmission during dental aerosol-generating procedures (AGPs) (< 5 μm) became a prominent concern. Accordingly, many countries recommended the suspension of dental services for several weeks beginning mid-March 2020.[6–8] During this period, it was recommended to limit dental care to emergency and urgent dental conditions, postpone non-urgent dental procedures, and avoid AGPs. Six weeks later, professional organizations and governmental bodies had published new guidelines for dental practices tailored to the pandemic, including infection control.[9,10] In those guidelines, personal protective equipment (PPE) recommendations varied according to the assessment of the dental patient's COVID-19 risk, the dental procedure, and PPE availability. One of the areas of controversy was the recommendation to use a class 2 filtering facepiece class 2 (FFP2) or FFP3 respirator during dental procedures.[11–14] Together with that, many COVID-19 patient triage questionnaire tools were developed.[15,16] The resumption of dental services near the end of April 2020 was accompanied by considerable fear and anxiety on the part of dentists.[17–19] One study reported that 58% of the dentists who decided not to resume their treatment of dental patients during COVID-19 did so because of fear for their own health.[17] The Occupational Safety and Health Act (OSHA) occupational risk pyramid for COVID-19 classified dentists among those with a " … very high exposure risk for known or suspected sources of COVID-19." DHCP are at risk of COVID-19 infection because of the nature of dental procedures, particularly when performing AGPs, having close contact with the patient, and exposure to known or suspected sources of COVID-19.[20] Despite those fears and occupational risks of infection, a recent study the American Dental Association (ADA) Science and Research Institute conducted in June 2020 reported that dentists' risk of contracting COVID-19 was approximately 0.9%.[21]

A plethora of published studies has surveyed the knowledge, attitude, and behaviors of DHCP and dental patients during the COVID-19 pandemic.[17,18,21–32] Umeizudike et al reported a positive attitude among Nigerian dental students regarding infection control practices, however, their knowledge was just adequate.[24] Variation in knowledge regarding COVID-19 among Saudi dental professionals was most observed regarding the virus survival and handwashing hygiene practice.[29] Although surveys are a valid study design, and convenient, particularly during a pandemic, there is an inherent bias when participants self-report practices such as infection control measures. For example, one of the biases is the social desirability bias in which people tend to over-report positive outcomes. To date, studies in the literature that involved direct observation of infection control measures among DHCP were published before the emergence of COVID-19.[33] In contrast, the objective of this study was to compare dental students' compliance with infection control practices pre-COVID-19's outbreak and during the pandemic, and investigate factors that affected compliance with these recommended practices. Hence, this study assessed infection control measures through direct observation of dental care provision both in 2019, before the COVID-19 outbreak, and in 2020, during the pandemic. The hypothesis was that dental students' compliance with infection control standards would not differ before the outbreak of COVID-19 and during the pandemic.

Methodology

Study Design

The Ethics Review Committee of the King Abdulaziz University Faculty of Dentistry (KAUFD) approved this cross-sectional study (Approval number 119-11-20), which involved prospective direct observation of dental students' compliance with infection control measures at a dental school during two consecutive academic years: 2019 and 2020. Each year, data were collected from September to December. The 2019 data were considered the pre-COVID -19 observations, while the 2020 data were regarded as the during COVID-19 observations. The number of targeted infection control audits was decreased strategically in 2020 to maintain social distancing and avoid unnecessary crowding during active clinical sessions. Infection control practice is taught as part of the practice management course at the beginning of the fourth year (just before students begin to treat actual patients in the clinic). A lecture and hands-on training about infection control measures included proper PPE, hand hygiene, sterilization and disinfection, sharps safety, and waste disposal, which is reinforced through annual clinical orientation sessions.

Study Sample

The study sample was comprised of junior (4th- and 5th-year) and senior (6th-year) dental students (2019: n=504;

2020: n=552) practicing in the student clinics at KAUFD in Jeddah, Saudi Arabia.

Data Collection

The dental students were observed for adherence to infection control standards while treating actual patients in their clinical sessions. To minimize the Hawthorne effect, they were unaware that an infection control audit would be performed, as it was not a scheduled activity. The students were audited for adherence to infection control practices during their clinical sessions as part of the school's routine clinical quality assurance measures. The auditors attended an infection control lecture and an interactive training session to achieve standardization and calibration. One auditor performed a single audit at a time. The auditor introduced him/herself to the dental student and asked the student for permission and consent to audit the clinic.

The checklist used to assess compliance with infection control practices was adapted from the Infection Prevention Checklist for Dental Settings the Centers for Disease Control and Prevention (CDC) published;[34] specifically, two subsections in the section entitled "Direct Observation of Personnel and Patient-Care Practices"—"hand hygiene is performed correctly" and "PPE is used correctly"—were used. Each infection control practice was rated as pass, fail, or not applicable. Gender, year of study, type of procedure, and grade point average (GPA) were collected. The school uses a 5.0 GPA scale on which 4.50–5.0 represents (A), 3.75–4.49 (B), 2.75–3.74 (C), 2.00–2.74 (D), and below 2.00 (F).

Statistical Analyses

The primary dependent variable was the number of infection control violations observed, which was recorded as the total number of fail marks for each of the elements in the infection control checklist observed. All statistical analyses were performed using SPSS v. 24 (IBM-SPSS Inc., Armonk, NY). This variable was not distributed normally, as assessed by the Shapiro–Wilk test ($p<0.0001$). Therefore, Mann–Whitney *U*-tests were used to determine whether there were any significant differences in the number of violations based upon year, gender, or student seniority (whether the student was a junior or senior-year student). Chi-square tests or Fisher Exact tests, as appropriate, were performed to compare dental students who had infection control violations with those who had no violations. Spearman correlation was used to assess the correlation between the number of violations and GPA. A multiple linear regression was performed to predict which variables were determinants of the number of infection control violations with the level of significance set at $p<0.05$. The dependent variable was the number of violations based upon the total number of observations that warranted a failure score. The main independent variable was the academic year (pre-COVID-19 outbreak versus during the pandemic). Others included the dental students' gender, seniority, and GPA.

Results

Over the 2 years of the study, 622 infection control audits were performed: 410 in 2019 (pre-COVID-19) and 212 in 2020 (during the pandemic). Table 1 lists the participants' characteristics. Approximately 56% of the entire sample were female and the mean GPA was 4.2 (SD 0.5). The most common audited clinical procedures were restorative (77.7%) and periodontic procedures (13.2%).

Table 2 shows the percentage of violations for each item observed on the infection control checklist. The number of violations was significantly lower in 2020 (during the COVID-19 pandemic) than in 2019 (pre-COVID-19), 1.7% and 5.7%, respectively. The percentage improvement in the correct use of PPE varied from 22.2% to 100%, while improvement in hand hygiene practices ranged from 30.8% to 80.7%. The two most common violations during the pandemic were not wearing eye protection (11.1%) and not attending to hand hygiene immediately after removing gloves (9.4%). The most drastic improvement in PPE use was in wearing the protective gown (100%). The poorest improvement among the hand hygiene practices was washing hands before and after treating each patient (30.8%).

Dental students at KAUFD are required to use a surgical mask; however in 2020, nearly half used two masks, and the least common choice was a single mask (Figure 1). Female dental students were 1.6 times more likely to wear an N95 mask (OR 95% CI: 1.2 to 2.3) compared to males (X^2 p=0.001). In contrast, gender was not a significant factor in the use of one or two surgical masks. Before the pandemic's onset, the number of infection control violations per student ranged from 0 to 7 (mean of 0.6, SD=1.1); after onset (2020), violations ranged from 0 to 4 (mean of 0.4, SD=0.7). Figure 2 illustrates the changes in the number of violations before and after COVID-19's onset. When PPE versus hand hygiene practices violations were compared, PPE accounted for 4.6% in 2019 and 2.5% in 2020, while hand hygiene practices accounted for 7.5% in 2019 and 3.8% in 2020.

Table 1 Characteristics of Dental Students Observed for Compliance with Infection Control Measures During Their Clinical Sessions in 2019 (Pre-COVID-19 Outbreak) and 2020 (During the COVID-19 Pandemic)

		Pre-COVID -19	During COVID-19
	Total	2019	2020
	% (N) N= 622	% (n) n= 410	% (n) n= 212
Gender			
Male Female	43.6% (271) 56.4% (351)	41% (168) 59% (242)	48.6% (103) 51.4% (109)
Academic year			
Junior Senior	49.2% (306) 50.8% (316)	44.9% (184) 55.1% (226)	57.5% (122) 42.5% (90)
Type of Clinical Procedure			
Restorative Periodontic Examination Oral Surgery Emergency	77.7% (481) 13.2% (82) 6.6% (41) 2.4% (15) 0.5% (3)	76% (311) 12.5% (51) 8.3% (34) 2.9% (12) 0.5% (2)	81% (170) 14.8% (31) 3.3% (7) 1.4% (3) 0.5% (1)
GPA Mean (SD)	4.2 (0.5)	4.2 (0.5)	4.2 (0.4)

Bivariate analyses showed that the dental students audited in 2019 (pre-COVID-19) were 1.4 times more likely to have violated infection control practices compared with those in 2020 (during the COVID-19 pandemic). Further, significantly more infection control violations occurred in 2019 compared to 2020 (Mann–Whitney *U*-test, p=0.04). However, there were no significant differences in the number of violations by seniority. Female dental students were 2.9 more likely to incur a violation compared to male dental students (X^2 p<0.0001). GPA was also found to be correlated with the number of violations (Spearman correlation coefficient = 0.1, p=0.01). A multiple regression model (Table 3) showed that the fewest infection control violations occurred among male dental students in 2020, during the pandemic (regression model p<0.0001). GPA was no longer a significant predictor in this regression model.

Discussion

This study found that dental students at KAUFD improved in their compliance with infection control standards during the COVID-19 pandemic (2020) compared to the previous year (pre-COVID-19 outbreak). The improvement ranged from 30.8% for "washing hands before and after treating each patient" to 100% for "wearing protective clothing". Female dental students committed more infection control violations than did males. Further, it was interesting to observe the variation in the preference for masking, as approximately half of the dental students opted to use two surgical masks in 2020, and 39.2% preferred to use N95 masks, while a single surgical mask was the least preferred. The dental school protocol was to wear a single surgical mask; however, students who opted to use two surgical masks were allowed to do so and this was not considered a violation. Compliance with recommended hand hygiene practices improved from 92.5% in 2019 to 96.2% after the pandemic was declared. The item in the hand-hygiene list that improved least was "before and after treating each patient". However, among the hand hygiene items, the students complied least in performing hand hygiene "immediately after removing gloves", which was 83.6% in 2019 and 90.6% in 2020.

Pre-COVID-19 compliance with infection control practices was quite reasonable in this study (mean 94.3%). This percentage is slightly higher than in another Saudi Arabian study, which reported 89% infection control compliance among the dentists surveyed before the COVID-19 pandemic.[28] This study found an improvement in infection control practices among dental students during the pandemic compared to the preceding year. This improvement is consistent with the ADA study that reported improved infection control practices in 99.7% of US dentists during the pandemic.[21] Other studies have reported that 64–90% of dentists surveyed demonstrated improvement in their PPE routines after the WHO declared COVID-19 a -pandemic.[25,28] Dentists' heightened awareness of the importance of infection control during the pandemic explains this improvement.[28] Researchers in Jordan also observed Jordanian dentists' greater awareness of COVID-19 transmission and infection control measures (97.6% compliance).[23] Moreover, Nasser et al reported that 91.3% of Lebanese dentists were well informed about COVID-19.[22] Another possible explanation for improved compliance is the fear of acquiring COVID-19 during dental procedures, which ranged from 78%[18] to 94.7%.[35] The emphasis on infection control training and quality control measures during the pandemic may also have contributed to the improved compliance observed.

Table 2 The Infection Control Checklist[a] and Number of Dental Students' (DS) Violations

	Pre-COVID-19	During COVID-19		
	2019	2020	Percent Improvement	*p*-value[b]
	% (n)	% (n)		
1. PPE is used correctly				
1.1. PPE is removed before leaving the work area.	1.9% (6)	1.1% (2)	42.1	0.7
1.2. Hand hygiene is performed immediately after removal of PPE.	10.1% (31)	3.8% (7)	62.4	0.008*
1.3. Masks, protective eyewear, and face shields:				
1.3.1. DS wears eye protection with solid side shields or a face shield during procedures that are likely to generate splashes or sprays of blood or other body fluids.	16.4% (59)	11.1% (21)	32.3	0.06
1.3.2. DS changes masks between patients and during patient treatment if the mask becomes wet.	2.8% (6)	1.5% (2)	46.4	0.3
1.4. Gloves:				
1.4.1. DS changes gloves between patients.	0% (0)	0% (0)	-	-
1.4.2. DS removes gloves that are torn, cut, or punctured and performs hand hygiene before putting on new gloves.	3.3% (8)	1.9% (3)	42.4	0.3
1.5. Protective clothing				
1.5.1. DS wears protective clothing (eg, disposable gown).	1.3% (5)	0	100	0.1
1.5.2. DS changes protective clothing if visibly soiled immediately or as soon as possible if penetrated by blood or other potentially infectious fluids.	0.9% (2)	0.7% (1)	22.2	0.7
2. Hand hygiene is performed correctly				
2.1. When hands are visibly soiled.	1.7% (5)	0.6% (1)	64.7	0.3
2.2. After barehanded touching of instruments, equipment, materials and other objects likely to be contaminated by blood, saliva, or respiratory secretions.	3.1% (9)	0.6% (1)	80.7	0.06
2.3. Before and after treating each patient.	2.6% (7)	1.8% (3)	30.8	0.4
2.4. Before putting on gloves.	13.9% (47)	6.4% (13)	54.0	0.004*
2.5. Immediately after removing gloves.	16.4% (54)	9.4% (20)	42.7	0.04*

Notes: [a]Adapted from the Infection Prevention Checklist for Dental Settings, the Centers for Disease Control and Prevention, USA. [b]*p*-value of Fisher exact tests. *Indicates statistical significance.

Abbreviation: PPE, Personal Protective Equipment.

In this study, 39% of the dental students used N95 masks in 2020. This proportion lies between that reported in a Turkish study (12%)[26] and another multinational study (89%).[18] N95 masks are designed to protect the wearer from aerosols and have a filtration capacity of 95% for 0.3-micron particles.[36] However, the recommendation to use FFP2, such as an N95 mask, during dental patient care, is controversial.[11,13,14] Cochrane's recent rapid systematic review reported that only 18% of its sources recommended the use of an FFP2 for unsuspected COVID-19 patients, and this proportion rose to 59% of the sources when an unsuspected COVID-19 patient was undergoing an AGP.[11] Another review of European dental association protocols found that 54% of European countries recommend the use of FFP2/FFP3 when AGPs are performed on an asymptomatic patient.[13] Some guidelines recommend the use of

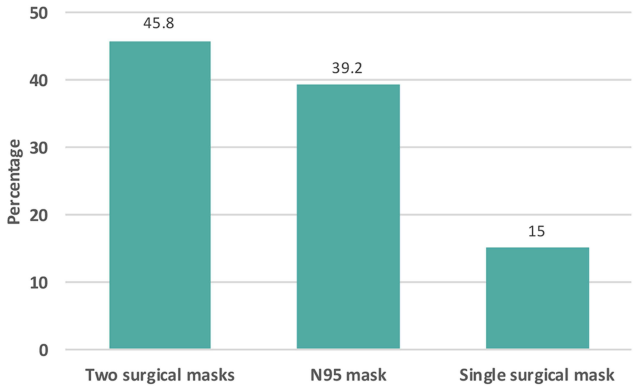

Figure 1 Type of masking chosen by dental students at a dental school in Saudi Arabia during the COVID-19 pandemic.

N95 masks as PPE during routine dental care and particularly during AGPs,[13,15,37–39] while others have found the use of a surgical mask sufficient in routine dental practice.[11,40] There is consensus on the use of an N95 mask when a dentist is treating a patient who is suspected of having or is positive for COVID-19.[11,41] The choice to wear a mask in a dental setting also depends upon availability and prioritization of their use, as a short supply in N95 masks and PPE has been reported in some areas.[42] It is interesting that 72% of dentists surveyed in Saudi Arabia believed that the N95 should be routine PPE in the future.[28] Approximately 46% of the dentists in this study used two surgical masks. Lazaridis et al recommended the use of a second surgical mask that could be removed after each patient encounter.[43] Another study recommended wearing a disposable surgical mask over the N95 or any FFP2.[39] It was encouraging to observe that 100% of our dental students wore a disposable gown, which is school policy. The 16 May 2020 version of the Cochrane rapid review states that 29% of its sources recommended the use of disposable gowns when treating unsuspected COVID-19 patients, 65% recommended it when performing AGPs in unsuspected cases, and 47% in suspected or confirmed COVID-19 cases.[11] With the increased concern about COVID-19 infection with AGPs, alternative procedures that use minimally invasive treatments have been recommended when treating early childhood caries during the pandemic.[44]

There is universal agreement about the importance of hand hygiene, particularly during the pandemic. In a recent publication, European oral surgery specialists were in consensus about the importance of hand hygiene to decrease the risk of COVID-19 transmission in dental settings.[14] However, the literature has demonstrated that compliance with hand hygiene is not as high as desired and ranges from 35% to 56%.[45–47] In this study, compliance with hand hygiene improved from 92.5% in 2019 to 96.2% in 2020.

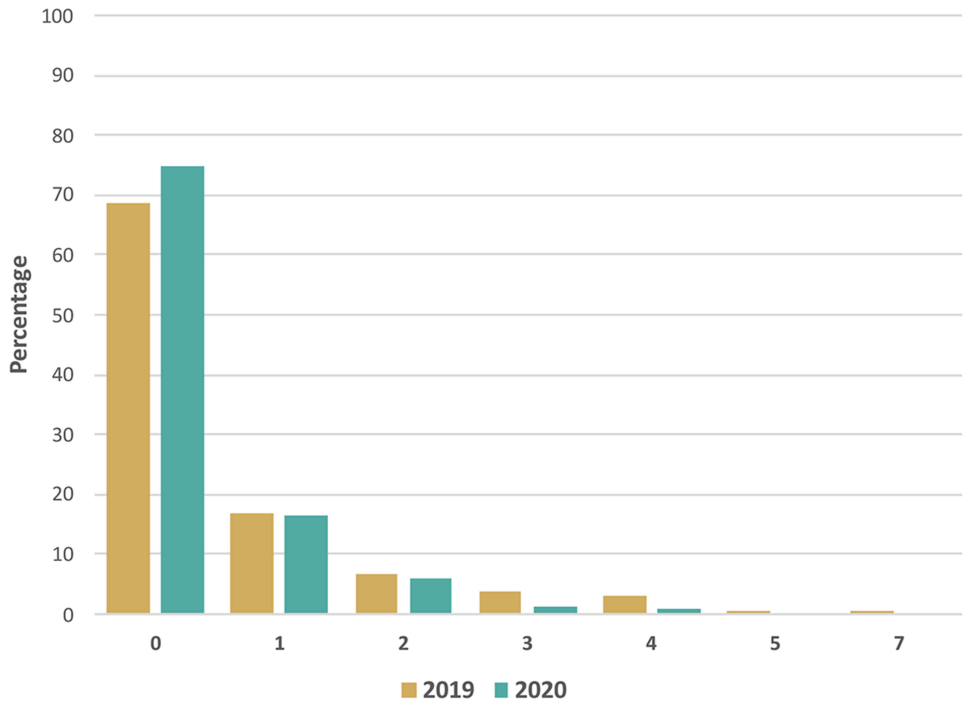

Figure 2 Comparison of infection control violations between pre- and during COVID-19 pandemic data by dental students.

Table 3 Multiple Linear Regression Model for Predicting the Number of Infection Control Violations by Dental Students Before and After the Declaration of the COVID-19 Pandemic by the World Health Organization

Predictors	Reference Group	β	SE	Standardized β	95% CI	*p*-value
Year[a]	2019 (pre-COVID-19)	−0.2	0.09	−0.1	(−0.4, −0.05)	0.01*
Seniority	Junior	−0.07	0.09	−0.03	(−0.2, 0.1)	0.5
Gender[b]	Female	−0.4	0.1	−0.2	(−0.6, −0.2)	<0.0001*
GPA	-	−0.01	0.1	−0.004	(−0.2, 0.2)	0.9

Notes: [a]Year: 2019 (pre-COVID-19) as the reference group versus 2020 (during COVID-19 pandemic). [b]Gender: Female versus male. * Indicates statistical significance.
Abbreviation: CI, Confidence Interval.

With respect to adherence to infection control standards according to gender, it was interesting to find that more male than female dental students were compliant. This is consistent with Mutters et al, who reported that more male than female DHCP in Germany complied with infection control standards.[33] In contrast, Cheng et al reported that female dentists in Taiwan tended to be more adherent to infection control practices.[30] The choice of the mask also varied by gender in this study, as female dental students were more inclined to use N95 masks compared to males. This finding agrees with those of a recently published study that surveyed dentists practicing in Saudi Arabia.[28]

This study has several strengths. It estimated compliance with infection control recommendations through direct observation in dental clinics before and during the COVID-19 pandemic rather than relying on self-reported infection control practices through surveys. This minimizes the risk of social desirability, recall, and information biases, which tend to overestimate appropriate behaviors. Another strength is the sample size of this study, which is representative of KAUFD dental students' demographics. Further, using the CDC infection control checklist as the instrument allowed comparison with international standards. Limitations specific to this study include investigating adherence to infection control standards among dental students only, which may limit the ability to generalize the results to educational dental settings. Further, extrapolation of the study findings to practicing dentists and private clinic settings may not be feasible. Another limitation is the fact that dental students could see that they were observed and act accordingly, ie, the Hawthorne effect. However, the audits were performed without prior scheduling and the dental students were observed during a clinical procedure. Accordingly, changing the PPE situation was not a concern, but was when observing hand hygiene practices. The fact that the sample size of the groups before and after COVID-19 were unequal is also another limitation, as it could reduce the study's power. However, each group included more than 200 subjects, and therefore, was not a major concern. This differential sample size was planned strategically during the COVID-19 period to maintain social distancing and avoid unnecessary crowding during active clinical sessions.

Conclusion

In conclusion, compliance to infection control measures, as determined through direct observation, improved between 2019 and 2020, before and after the WHO declared COVID-19 as a pandemic. Compliance with pandemic recommendations for PPE was higher than with hand hygiene practices. This indicates the need for periodic reinforcement and training with an emphasis on hand hygiene practices. Male dental students were found to be more compliant with infection control standards than females, although interestingly, more female than male dental students preferred to use N95 masks. Future studies are suggested that investigate gender differences in compliance with infection control standards in dentistry and the choice of a mask. Our findings have important clinical implications in designing strategies to improve dental students' compliance with infection control standards, particularly hand hygiene practices, and in educating them about the current evidence and recommendations with respect to masking choices.

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Disclosure

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