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Practices of personal protective equipment use among final-year dental students: a cross sectional study

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Abstract

Background and objectives: The correct use of personal protective equipment (PPE) is an essential component of safe clinical practice in dentistry. This study examined the PPE practices of final-year dental students during clinical sessions.

Methods: Twenty-four final-year dental students (89% response rate) were video recorded during clinical sessions with patients over 18 years of age. Observations of practices as applied to PPE use were scored. Data included: age, gender, length and type of procedure, PPE application and removal, tying back of long hair, as well as operator contact with PPE, equipment, computer and workspace surfaces.

Results: The front of facemasks were frequently touched with gloved hands while the straps ($p<0.05$) were not. Eye protection was worn by all student practitioners, with over half of the participants (13/24) not touching their eye protection throughout the recordings. There was no observed difference between the type of eye protection used, procedure carried out, or gender in relation to gloved hand mean touches per 60 minutes ($p>0.05$). While almost all participants had clean and dirty zones and correct donning and doffing of PPE, the majority of participants touched 'other surfaces' which were defined as dental drawers, dental products, the operator's chair, tweezers, keyboard, mouse, or gown.

Conclusions: A small proportion of students' habits should be reviewed, and corrective actions highlighted in order to improve cross infection protocols, improve hand hygiene, and to reduce transmission of potentially infectious agents, thus reducing potential harm to both clinicians and others. All clinicians should be mindful of correct PPE use and cross infection control procedures.

Introduction

Infection control procedures are paramount to safe clinical practice in dentistry. The emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has highlighted this for dental professionals, who have contact with saliva and use drills, ultrasonic scalers and the triple syringe which create droplets that can spread the virus (Bentley *et al.*, 1994; Harrel & Molinari, 2004). These droplets can travel several metres and potentially contaminate surfaces including the operator, workspaces and equipment. Studies suggest SARS-CoV-2 can be viable in aerosols for up to 3 hours and stable on contaminated surfaces for up to 3 days (Morawska *et al.*, 2009; Morawska & Cao, 2020; Van Doremalen *et al.*, 2020). Other modes of transmission include inhaling aerosols, splashes/droplets of blood contaminating via non-intact skin, or through mucous membranes of eyes, mouth, or nose. Clinicians must also be cognisant of when these surfaces come in contact with contaminated skin, for example rubbing eyes when their hand is contaminated with pathogens, and needle-stick injuries through intact skin (Siegel *et al.*, 2007).

There is abundant evidence showing that hand hygiene and correct personal protective equipment (PPE) use and habits are effective measures to reduce the transmission of infectious agents (Siegel et al., 2007). Hand hygiene is one of the most important practices in reducing transmission (Sax *et al.*, 2009; Magiorakos *et al.*, 2010). "Hand hygiene" includes handwashing with water and a plain or antiseptic-containing soap, and the use of an alcohol-based hand rub (ABHR) in the form of gels, rinses and foams absent from water (Boyce & Pittet, 2002; *Infection prevention and control practice standard*, 2016). Where there is no visible soiling of hands, an ABHR is preferred over a wet hand wash due to better microbicidal control (Boyce & Pittet, 2002).

PPE options to aid in reducing the risk of transmission of infectious agents include facemasks, face shields, respirators, gloves, gowns and eye wear. The typical PPE for a dental practitioner involves personal eyewear, surgical mask, gloves, and gown, which act as a physical barrier to protect from sprays and splatter to mucous membranes, exposed body areas and clothing (Siegel et al., 2007). Surgical masks are designed to filter droplets/particles with diameters >100 nm (Smereka *et al.*, 2020), where SARS-CoV-2 particles are typically 90 nm (Laue *et al.*, 2021). Both the outside surface and inside surface of facemasks are areas of saturation for infectious agents, such as bacteria and viruses. Microorganisms can stay on these surfaces for long periods of time, as a result of the high humidity and temperatures provided by the wearer, thus accelerating the penetration and spread of microorganisms to the inner parts of the mask (Smereka et al., 2020; Yi *et al.*, 2005).

Proper techniques for putting on (donning) and taking off (doffing) PPE using the Centers for Disease Control and Prevention (CDC) guidelines lead to less contamination (*Protecting healthcare personnel*). The proper donning technique is as follows: (1) Hand

hygiene; (2) Gown; (3) Face mask/respirator; (4) Goggles/face shield; (5) Gloves.

The correct doffing of PPE is as follows: (1) Remove gloves with appropriate technique to limit contamination of hands such as glove-in-glove; (2) Remove gown; (3) Perform hand hygiene; (4) Remove goggles/face shield; (5) Remove mask/respirator by carefully untying or unhooking from ears and pulling away from the face without touching the front of mask; (6) Repeat hand hygiene.

Guidelines for the use of PPE in dentistry have been published by organisations such as the Dental Council of New Zealand (DCNZ) and Australian Dental Association (ADA). The purpose of these guidelines is to prevent and reduce the transmission of infectious agents such as bacteria, fungi, and viruses (*Guidelines for infection prevention and control*; *Infection prevention and control practice standard*, 2016). It is critical that routine infection control measures are consistently performed in order to eliminate or reduce the transmission of infectious agents in the oral health care setting and prevent transmission between any individual and location. This research aimed to investigate the PPE practices of final-year dental students during clinical sessions and provide valuable guidance to clinicians on improving or confirming their clinical practice in relation to preventing the spread of SARS-CoV-2 and other transmissible diseases. Our hypothesis was that all participants would adhere to cross-infection control guidelines.

Materials and methods

Participants and consent

Ethics approval was obtained from the University of Otago Human Ethics Committee (D21/075). 'Primary participants' were all final-year dental students, in the middle of their 5th year, attending the University of Otago Auckland Dental Facility, while 'other participants' involved were patients, dental assistants and tutors. Participants were excluded from the study if they did not consent to being video recorded or were under 18 years of age. Consent was required from other participants as they could fall within the field of the video and thus be identified in the recording. Information sheets outlining the study were given to participants, and written consent was obtained from all participants. Personal information collected from the primary participants included gender and age. There was a response rate of 89 % (24 out of 27 students) from the primary participants and all other participants consented. The information collected regarding final-year dental students' clinical practice in relation to PPE use was anonymised and did not affect/influence the students' grades or final assessments. All participants were able to freely choose to consent/not consent and withdraw their consent at any time. All data was stored in a locked cupboard or a secured computer.

Data collection

Clinical sessions were recorded, and the sequencing of PPE application and removal was investigated, along with whether contact occurred with potentially contaminated surfaces. Participants were recorded with an Olympus Tough camera via an Elegato HD60 S+ capture card and screen recorded using OBS studio with MKV being the file format. Recordings captured an entire clinical session for 24 students. Procedures being conducted included examinations, extractions, restorative and hygiene procedures which were allocated to time slots of 1.5 or 3 hours. The camera was situated side on from participants on a benchtop, as far away from the operator/patient as practical. The video frame for the recordings included all benchtops, computer, drawers, dental chair, the operator and others.

Data analysis

Participants were randomly assigned an operator number using a Microsoft Excel "=Rand()" function from 1 to 24 to allow for de-identification, where only the main observer knew the assigned numbers. All video recordings were reviewed using a standardised scoring sheet to record the type and length of procedure, whether long hair was tied back, number of times the operator's gloved hand touched their face mask (straps or front), type of eye protection and number of gloved hand touches to eye protection (glasses, arms of glasses, light, loupes), number of times the operator's gloved hand touched items in the environment including dental drawers, dental products, the operator's chair, tweezers, keyboard, mouse, gown, and number of operator gloved hand contacts with sterile/non-sterile surfaces, and areas, as well as the sequence of PPE donning and doffing.

The analysis took into consideration the two zones in a clinical working environment, referred to as the contaminated zone and clean zone (*Guidelines for infection prevention and control*; *Infection prevention and control practice standard*, 2016). A 'contaminated zone' is an area of work where direct or potential contamination with patient fluids (blood body fluids, including saliva) by transfer, splashing, or splatter of material can occur (*Guidelines for infection prevention and control*). A 'clean zone' is any other area in the practice environment. This includes drawers and surfaces where clean, disinfected, and sterilised instruments are stored which should not contact contaminated instruments or equipment (*Guidelines for infection prevention and control*). Whether students had clearly demarcated contaminated and clean zones was recorded.

All data was collected in Excel and the number of touches to various surfaces with a gloved hand normalised to a 60 min timeframe. Graphs and analysis of findings were conducted in GraphPad Prism 9.2.0 (GraphPad Software Inc., San Diego, CA, USA). One-way ANOVA and Tukey's multiple comparisons tests were conducted and statistical significance set at $p<0.05$.

Results

The length of video recordings ranged from 40 to 160 min. There was no direct indication that the videorecording affected the clinical procedure being performed. A total of 71% (17/24) of the participants were between the ages of 22-25 years, with the mean age being 24 years, and range of 11 years. This age distribution did not allow for a meaningful comparison based on age group.

The 24 procedures conducted by the students consisted of: examination (n=1), extractions (n=2), hygiene (scaling/debridement; n=7), restorations (n=9) and root canal treatment (n=5), with restorations and hygiene making up over half of appointments. The majority of participants (19/24) did not work with a dental assistant with only 5 participants noted to work with a dental assistant.

All student clinicians used some form of eyewear. Eye protection type varied and included prescription glasses (n=11), safety glasses (n=3), safety glasses with light (n=2), loupes (n=1) and loupes with a light (n=7). The extent of eyewear and mask touching with gloved hands was examined. Of the 24 primary participants there were n=6 who touched their mask, n=5 who touched their eye wear and n=4 who touched to both mask and eyewear.

Over half of the participants (13/24) did not touch their eye protection throughout the recordings (Figure 1). Of those that did touch their eyewear, there was a mean of 7.5 touches to eyewear per 60 minutes (SD ±7.3), with 4 operators touching their eyewear more than 7.5 times per 60 minutes (9.2, 12.0, 14.0, and 21.7 touches per 60 minutes). Some users with prescription glasses were found to adjust the angle frequently, while some operators with loupes and lights adjusted the angle and blue light filters particularly during restorative treatments. There was no statistically significant difference ($p>0.05$) between the gloved hand touches to different eyewear types (Figure 1).

Face masks were worn by all participants and 58% (14/24) did not touch any part of their mask throughout the procedure (Figure 2). No participants adjusted the straps of their facemask, instead the front of the mask was touched an average of 1.7 times per 60 minutes (SD ±3.2). In addition, two participants were identified with 11 and 12 touches per 60 minutes. There was no statistical difference between the procedure being conducted and contact with the clinician's face mask.

The mean number of total face mask and eye protection contacts was compared between genders with no statistical difference ($p>0.05$) detected (Figure 3).

Most student practitioners (n=20) had clearly marked zones to prevent cross-contamination with only four having zones that were difficult to distinguish. Incidents of cross-contamination of clean zones were observed by two students. One involved a glass ionomer capsule applicator and in the second dental dam forceps were placed in the clean area. There was also one instance where composite resin was dispensed onto a pad which had been in contact with the clinician.

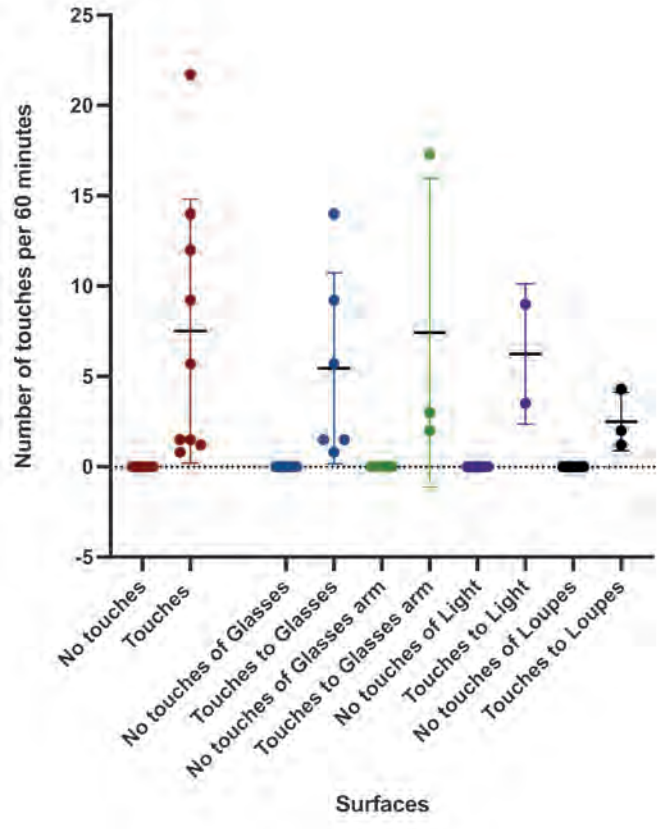

Figure 1. Number of eyewear touches normalised to 60 minutes of a clinical session as collected from 24 student clinicians. Mean ± SD.

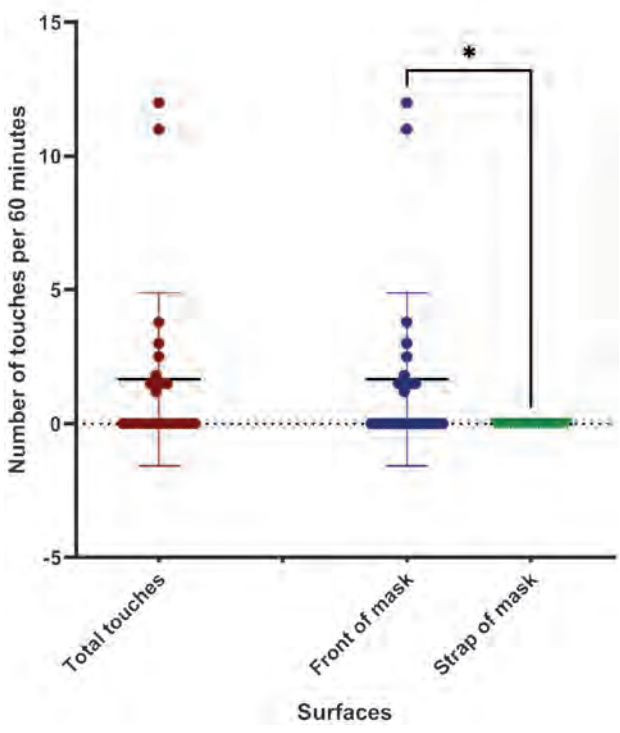

Figure 2. Face mask touching during procedures (n=24). * p = 0.049. Mean ± SD.

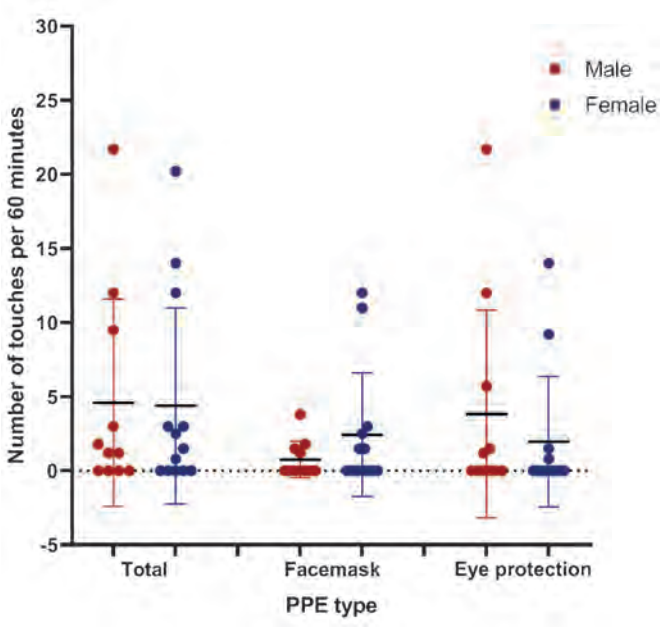

Figure 3. Facemask and eyewear protection touches by gender. Mean ±SD.

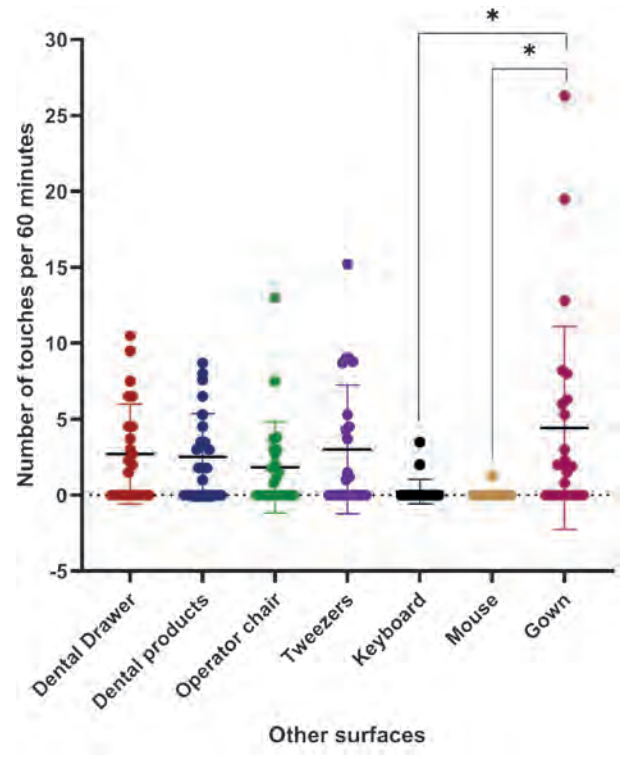

Figure 4. Student clinician touching of other surfaces. * $p<0.05$. n=24 per surface observed.

Other observations included two occurrences of container lids (carrying burs) not being closed during restorative treatment.

The majority of participants touched 'other surfaces' which were defined as dental drawers, dental products, the operator's chair, tweezers, keyboard, mouse, or gown. Only 13% (3/24) of participants did not touch any of these surfaces with a gloved hand. The number of participants touching at least one of the following surfaces were: dental drawers (n=13), dental products (n=14), operator's chair (n=12), tweezers (transfer tweezers) (n=12), keyboard (n=2), mouse (n=1) and gown (n=15). Half (12/24) of students were observed using transfer tweezers and elbows or gloved hands to open drawers. It was also very common to remove gloves and immediately type up notes or retrieving items from the drawer without an ABHR. Dental gowns (n=15) were touched by the highest number of participants, and had the highest mean touches per 60 minutes of 4.5 (SD ±6.7, Figure. 4). The high incidence of gloved hands on their gowns commonly occurred while waiting for a tutor or while dental materials were curing. There were no statistical differences ($p>0.05$) between the groups except between the gown and the computer equipment (Figure 4).

Donning and doffing of PPE was observed when possible. Prior to donning PPE, it was observed whether long hair, beyond the clinician's shoulders, was tied up. More than half of participants (14/24; 58%) met the criteria requiring their hair to be tied up, and all were observed to have done this. Not all donning and doffing habits could be observed, however 15 donning and 10 doffing procedures were captured. Of these, 79% (11/15) of donning and 70% (7/10) of doffing sequences were correct. The incorrect donning sequence was eye protection placed before mask placement, while incorrect doffing was removal of facemask before removal of eye protection.

Discussion

Awareness of the importance of infection control is essential for all dental practitioners. Overall, participants in this study adhered well to cross infection control guidelines, however there is a need for improvement in some practices. All students wore the correct PPE for the clinical sessions including eye protection, gowns and face masks. In an ideal situation, no touches with gloved hands would occur to any surfaces however this is unlikely to be realistic, particularly in a setting without dental assistants. The results suggest four out of 24 of the final-year student clinicians would require improvement in cross infection control in relation to eyewear or facemask contact as they had more than 10 contacts per 60 min. However, the results also suggest that touches to other surfaces were more frequent and that only three participants adhered to correct procedure. It would be expected that these values would decrease significantly with the presence of dental assistants, with the exception of perhaps touches to gowns and operator chairs.

One very commonly observed habit was removing gloves and immediately typing up notes or retrieving items from the drawer without an ABHR. The ADA recommends hand hygiene to be performed after the removal of gloves where the clinician is writing or typing up patient notes (*Guidelines for infection prevention and control*). The entire operator should be assumed to be contaminated. Thus, carrying out an ABHR will aid in reducing the load of potentially infectious agents. There was also a frequent habit of the participants resting their gloved hands on their gowns while waiting for a tutor or for curing of dental material. This should be avoided to minimise cross infection between gloves and gown.

There are various types of eye protection that offer different levels of protection, with personal eyeglasses considered to offer the least protection (Siegel et al., 2007). Eyes as well as other mucous membranes are particularly susceptible to infectious aerosols and droplets. Thus, the clinicians themselves pose a potential risk as a vector for the transmission of infectious agents. Of the 24 participants 46% were observed touching their eye protection. The type of eye protection did not affect the number of touches, however those with prescription glasses or loupes had slightly higher reported means. Four individuals touched their eyewear frequently; this was not confined to one type of eyewear. The recordings suggested that poorly-fitted prescription glasses could require more frequent adjustments throughout the appointment, while those with loupes and in particular lights, were more likely to adjust the angle, in addition to adjusting the blue light filter of the light especially during a restorative treatment. It is unclear if touches due to adjusting eyewear pose a direct risk to the clinician, although it clearly contaminates the eyewear. For the safety of patients, it is essential that all parts of the clinician's eye protection be decontaminated between patients, regardless of whether the clinician had direct contact with surfaces (*Guidelines for infection prevention and control*).

All touches of the facemask were to the front of the mask with no one adjusting the straps. Just under half of the student clinicians 42% (10/24) were observed touching their facemask. This is a particular concern as it puts both the clinician and patient at risk of exposure to SARS-CoV-2 and other transmittable diseases. The mean of 1.7 touches per 60 minutes is low, however infection prevention and control standards by the DCNZ and ADA are in place to reduce the risk of transmission of potentially infectious diseases (*Guidelines for infection prevention and control*; *Infection prevention and control practice standard*, 2016). The action of touching the facemask is not necessary and should not occur.

Other factors including gender and age were considered. Gender did not influence the number of touches to facemasks or eye protection. The limited age distribution prevented any meaningful analysis. The students were consented for this project and knew that their PPE use was being recorded. Even with this knowledge they appear not to have changed their infection control behaviours. Changing behaviours is challenging and clinicians should recognise the importance of embedding correct practice during their training.

Clean and contaminated zones should be clearly demarcated to prevent any cross-contamination during clinical procedures. The majority of students had clearly-demarcated clean and contaminated zones. Four student practitioners had clean and dirty zones which were either hard to distinguish, or were mixed together. Any surface touched by the clinician is considered contaminated (*Guidelines for infection prevention and control*). Two participants caused cross-contamination between non-sterile instruments and clean zone on separate occasions. One involved a glass ionomer capsule applicator and in the second dental dam forceps were placed in the clean area. The entire clean zone in this scenario would be contaminated, potentially contaminating all clean products/surfaces.

With high aerosol generation, especially during scaling and/or restorative procedures, all drawers/containers should be closed during treatment, plastic coverings of keyboards should be changed between patients (or wiped if possible), and a thorough wipe down procedure should be carried out from the 'cleanest' to the 'dirtiest' surface (*Guidelines for infection prevention and control*). There were two instances where container lids (carrying burs) were not closed during aerosol producing restorative treatments. Aerosols can travel a considerable distance and practitioners need to be vigilant to ensure that sterile products are stored correctly (Bentley et al., 1994).

All participants that were required to do so, tied up their long hair prior to donning. The CDC advises to remove the mask by the straps to avoid contact with the front of mask. Additionally, it is ideal to follow the recommended procedures when donning and doffing to reduce infectious loads (*Protecting healthcare personnel*). An ABHR should be performed, if there is contact with the facemask, and after removal of facemasks/PPE. During donning and doffing, some incorrect practices were observed. While the majority of observed donning sequences were correct, 21% (4/15) were incorrect as eye protection was put on prior to the facemask. There were also 30% (3/10) incorrect doffing procedures where facemasks were removed before eye protection. It is however unclear what the implications of these minor variations in donning and doffing would be.

Good hand hygiene is imperative to reduce transmission of potentially infectious agents between the patient, clinician, and the clinical environment (Siegel et al., 2007). Clinicians should undertake an ABHR prior to gloving and after degloving unless there is visible soiling, in which case soap and water is preferred (Fallahi *et al.*, 2020). Operators should avoid using tweezers with gloved hands (transfer tweezers) or using elbows to open drawers in order to retrieve items as there is a high risk of contamination of clean surfaces and products. There was also one instance where composite

resin was dispensed onto a pad which had been in contact with the clinician. Ideally, a dental assistant would help retrieve and dispense dental products, which would reduce risk. The recommendation is to either remove gloves, proceed with an ABHR and retrieve the necessary products and materials with transfer tweezers where appropriate, or ideally, prepare prior to the treatment to reduce risk of cross-contamination.

This study was performed in the setting of a dental hospital, with a lack of chairside assistance. The student practitioners had limited experience with a small number of procedures, all factors that are different from private general practice, and are limitations of this research.

This research indicated that while many final-year dental student practitioners followed good PPE procedures, a small number would benefit from reflective learning while in the clinical setting. This could include practical sessions at the start of the BDS program and reinforcement of cross infection control during simulation clinics and during clinical sessions. The value of recording and reviewing clinical sessions was also demonstrated by this research. SARS-CoV-2 is timely reminder of the importance of clean and dirty zones and the practitioner's role in protecting patients and those within the clinical environment.

Conclusion

The nature of clinical dentistry makes it impossible to eliminate all risks of cross-contamination. However, clinicians and future clinicians should follow the guidelines and protocols strictly set out by their dental authority. A small proportion of students had habits which should be reviewed and corrective actions highlighted in order to improve cross infection protocols and improve hand hygiene to reduce transmission of infectious agents, thus reducing the potential for harm to both clinicians and others, particularly patients. Clinicians should ensure their eyewear is decontaminated between patients and be diligent in not touching the front of their facemasks as this poses a particular risk to the patent and the clinicians. Whether or not breaches of cross infection resulted in subsequent infection transmission was not examined in this research, however this research highlights areas where practice could be improved to lower risk.

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Conflicts of Interest

None

Authorship

Kelvin Jin: data collection, data analysis and interpretation, drafting the article, final approval to be published.

David M. Roessler: conception and design, revision of the article, final approval to be published.

Warwick J. Duncan: conception and design, revision of the article, final approval to be published.

J. Neil Waddell: conception and design, revision of the article, final approval to be published.

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