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Supplemental material is available online.

Assessment of dental health care personnel protocol deviations and self-contamination during personal protective equipment donning and doffing

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ABSTRACT

Background. Dental health care personnel (DHCP) may be at increased risk of exposure to severe acute respiratory syndrome coronavirus 2, the virus that causes COVID-19, as well as other clinically important pathogens. Proper use of personal protective equipment (PPE) reduces occupational exposure to pathogens. The authors performed an assessment of PPE donning and doffing practices among DHCP, using a fluorescent marker as a surrogate for pathogen transmission.

Methods. Participants donned PPE (that is, disposable gown, gloves, face mask, and eye protection) and the fluorescent marker was applied to their palms and abdomen. DHCP then doffed PPE according to their usual practices. The donning and doffing processes were video recorded, areas of fluorescence were noted, and protocol deviations were assessed. Statistical analyses included frequency, type, and descriptions of protocol deviations and factors associated with fluorescence.

Results. Seventy DHCP were enrolled. The donning and doffing steps with the highest frequency of protocol deviations were hand hygiene (66% of donning and 78% of doffing observations involved a deviation) and disposable gown use (63% of donning and 60% of doffing observations involved a deviation). Fluorescence was detected on 69% of DHCP after doffing, most frequently on hands. An increasing number of protocol deviations was significantly associated with increased risk of fluorescence. DHCP with a gown doffing deviation, excluding doffing out of order, were more likely to have fluorescence detected.

Conclusions. DHCP self-contamination was common with both donning and doffing PPE.

Practical Implications. Proper use of PPE is an important component of occupational health.

Key Words. Masks; eye protective devices; gloves, protective; health, occupational; dental infection control; COVID-19.

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Dental health care personnel (DHCP) may be at increased risk of occupational exposure to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19, and other pathogens of clinical importance owing to exposure to saliva, close contact with unmasked patients, and performance of aerosol-generating procedures.[1] Similarly, methicillin-resistant *Staphylococcus aureus* is a pathogen of clinical importance to which data suggest DHCP may be exposed.[2,3] In addition, risk of occupational exposure is not limited to methicillin-resistant *S aureus* and SARS-CoV-2, but may include a variety of viruses (respiratory, bloodborne) and bacteria.[3] The COVID-19 pandemic, however, has brought increased attention to the importance of personal protective equipment (PPE) for DHCP.

Centers for Disease Control and Prevention (CDC), Occupational Safety and Health Administration, and American Dental Association have published guidance for dental clinics on how to protect patients and DHCP from COVID-19 exposure and prevent transmission of SARS-CoV-2 in

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the oral health care setting.[4-6] A key component of all recommendations is implementation of universal PPE use to prevent transmission of SARS-CoV-2. The PPE items that the CDC recommended for DHCP include surgical mask, eye protection (either a face shield or goggles), gown, and gloves.[5] In addition, use of N95 respirators is recommended when performing aerosol-generating procedures.[5] However, some of these PPE components (for example, disposable gowns, face shields, and N95 respirators) were not used regularly in oral health care settings before the COVID-19 pandemic, and the processes for donning (putting on) and doffing (taking off) these items may be unfamiliar to DHCP. The purpose of our study was to assess DHCP risk of self-contamination when donning and doffing PPE as per CDC guidelines, using video evaluation of donning and doffing practices and fluorescent marker as a surrogate for viral pathogen transmission.

METHODS

The Washington University Human Research Protection Office and the St. Louis University Institutional Review Board approved this study. This study was performed at dental clinics in a US metropolitan area from September through November 2020 and from March through July 2021. Participating clinics included 1 hospital-affiliated pediatric dentistry clinic, 3 community-based general dental clinics, 3 community-based pediatric dental clinics, and 1 academic dental center. All DHCP at the participating clinics with clinical care responsibilities and experience using PPE were invited to participate. All study participants provided written, informed consent. The methods used in our study were adapted from a previous assessment of PPE protocol deviations during donning and doffing.[7]

PPE donning and doffing and contamination procedures

PPE items provided to DHCP to don and doff included safety goggles, face shields, disposable surgical or isolation-style masks, disposable gowns, gloves in multiple sizes, and alcohol-based hand sanitizer. Owing to COVID-19–related supply constraints, the brands of PPE available to participants varied during the study. All brands of disposable gowns used in this study had an opening for the head, thumb loops, and ties at the back of the gown. DHCP were allowed to don and doff with their own eye protection and mask if that was their preference, particularly if the DHCP used an N95 respirator routinely (N95 respirators were not provided as part of the study PPE). Some DHCP used additional PPE items (for example, hair covers) or personally owned specialty equipment (for example, loupes) and were encouraged to don and doff those items as well.

After providing consent, participating DHCP were scanned for baseline fluorescence under an ultraviolet light. The study team cleaned, when possible, and documented areas of baseline fluorescence. Areas of baseline fluorescence that could not be cleaned were noted and were not included in the postdoffing assessment. Most baseline fluorescence detected was fluorescent lint from dark-colored scrubs (particularly black, navy, purple) or fluorescent fingernail polish and was easily distinguished from study-related fluorescence. DHCP were then instructed to don PPE according to their usual practices; DHCP were not provided guidance during the donning process. Next, DHCP were instructed to close their eyes and a fluorescent marker was applied to their palms (both hands) and abdomen. Control applications of water were applied to both shoulders. An atomization device attached to a syringe was used to distribute the fluorescent marker and water as a fine mist over the PPE (more details are provided below). The fluorescent marker appeared opaque in the syringes compared with the water. DHCP were asked to close their eyes during applications so they would not be able to see which applications were fluorescence and which were water. Finally, after application of the fluorescent marker and water, DHCP were instructed to doff and dispose of their PPE according to their usual practices; again, no guidance or feedback was provided to DHCP during the doffing process.

The order and technique used to don and doff PPE were videotaped and recorded. After doffing, DHCP were scanned for fluorescence using ultraviolet light; any areas of fluorescence were photographed and recorded. Areas of fluorescence were assessed as dichotomous (that is, yes or no and presence or absence). Sites assessed included hands (front, back), wrists and arms (front, back), torso and chest, neck, face, and hair. Donning and doffing videos were reviewed and protocol deviations were noted. Deviations included performing a donning or doffing step out of order, not performing a donning or doffing step (for example, not performing hand hygiene), improper or lack of use of a PPE item (for example, not tying the gown or not using eye protection), and performing a

ABBREVIATION KEY

CDC:	Centers for Disease Control and Prevention.
DHCP:	Dental health care personnel.
PPE:	Personal protective equipment.
SARS-CoV-2:	Severe acute respiratory syndrome coronavirus 2.

Table 1. Donning and doffing sequence.

DONNING SEQUENCE	DOFFING SEQUENCE
1. Hand hygiene	1. Gloves
2. Gown	2. Gown
3. Face mask	3. Hand hygiene
4. Eye protection (face shield or goggles)	4. Eye protection (face shield or goggles)
5. Gloves	5. Face mask
	6. Hand hygiene

donning or doffing step in a manner that could result in self-contamination (for example, touching the front of the gown with bare hands). For hand hygiene, both the presence and absence of the step in the PPE process was assessed as well as technique (for example, rubbing the alcohol-based hand sanitizer between the fingers and not just on the palms and backs of hands). Protocol deviations were not assessed separately for different types of PPE within the same general category (that is, N95 masks vs surgical or isolation masks or goggles vs safety glasses). CDC guidance was considered the reference standard for the correct sequence of PPE donning and doffing steps (Table 1).[8] Additional picture-based guidance from the CDC is also available[9] and was referenced for this study. Each DHCP participated in the study only once.

Fluorescent marker

The fluorescent marker used in this study was Glo Germ Mist liquid (Glo Germ). One hundred μL of Glo Germ Mist was mixed with 0.5 mL of water and drawn into a 3-mL syringe with a needleless Luer-Lok tip (BD). A pediatric intranasal mucosal atomization device (LMA MAD Nasal; Teleflex) was attached to the syringe to deliver the fluorescent marker as a mist. The size and brand of syringes, needles, and atomizers used were consistent throughout the study. Syringes and needles were not reused. Atomizers were reused but atomizers used for water applications were kept separate from atomizers used for fluorescent marker applications.

Data analyses

Data were entered into Research Electronic Data Capture database.[10,11] The primary outcome of interest was factors associated with the presence of fluorescence after doffing PPE. Protocol deviations were grouped according to the step during which they occurred (for example, donning gloves and performing hand hygiene during doffing) and according to skill (for example, correct gown use). Total number of deviations was analyzed, excluding the deviations "donning out of order" and "no hand hygiene during donning." Donning out of order was excluded because this deviation often involved the DHCP donning their face masks first, before other PPE items, and the CDC donning sequence referenced for this study suggests performing hand hygiene and donning the gown before donning the mask.[8] Some of the participating DHCP preferred to don their mask first to minimize the amount of time they were unmasked; our study team judged this protocol deviation to be an acceptable variation on the CDC's donning sequence, owing to the risk of COVID-19 transmission and local mask mandates in place during the study period. The variable "no hand hygiene during donning" was excluded because the fluorescent marker was applied after donning and, therefore, hand hygiene during donning would not have had any impact on detection of fluorescence. Univariate logistic regression, χ^2 test, and Mann-Whitney U tests were used, as appropriate, and $P < .05$ was considered significant. Fisher exact test was used as appropriate. Data analyses were performed in SPSS software, Version 27 (IBM).

RESULTS

A total of 70 DHCP were enrolled in the study. Demographic characteristics of the study population are detailed in Table 2. Dental assistants and dental hygienists were the most common DHCP enrolled (54%) and dentists or dental residents accounted for 44% of participants. DHCP reported a variety of prior training with PPE, including no prior training, classroom or other training during clinical coursework, video-based training, and on-the-job training from coworkers, educators, or

Table 2. Demographic characteristics of study participants (n = 70).

CHARACTERISTIC	DATA
Female, No. (%)	55 (79)
Age, Y, Median (Range)	30 (19-70)
Type of Dental Health Care Personnel, No. (%)	
Assistant or hygienist	38 (54)
Pediatric dentist or resident	13 (19)
Dentist	6 (9)
Endodontist or resident	5 (7)
Periodontist or resident	4 (6)
Orthodontist or resident	3 (4)
Other	1 (1)
Clinic Type, No. (%)	
Academic dental	26 (37)
Community pediatric dentistry	25 (36)
Community dentistry	17 (24)
Hospital-affiliated pediatric	2 (3)
Years of Experience, Median (Range)	5 (< 1-45)
Left-Handed, No. (%)	3 (4)

managers. Eighty-six percent of participants reported having some prior PPE training, and 20% reported having more than 1 form of training (for example, on the job and classroom training).

The PPE donning steps associated with the most video protocol deviations were hand hygiene (66% of 82 observations involved a deviation), donning the disposable gown (63% of 70 observations involved a deviation), and donning the face mask (57% of 70 observations involved a deviation) (Table 3). The PPE doffing step most associated with protocol deviations was hand hygiene (78% of 78 observations involved a deviation), followed by doffing the disposable gown (60% of 70 observations involved a deviation) and doffing eye protection (face shield or goggles; 52% of 65 observations involved a deviation) (Table 2). Fluorescence was detected on 48 DHCP (69%) after doffing PPE (Table 3). Fluorescence was detected most commonly on the right (51%) and left (41%) hands.

Factors associated with detection of fluorescence were assessed (Table 4). There was no association with detection of fluorescence according to sex, type of DHCP, years of experience, prior PPE training, or total number of deviations (both when donning and doffing violations were considered separately and when combined). Median number of deviations was significantly higher among DHCP with fluorescence detected (median, 5 vs 3; $P = .03$). The relationship between protocol deviations according to category and fluorescence was also assessed. Having a gown doffing deviation (other than doffing the gown out of order) was significantly associated with detection of fluorescence (60% vs 23%; $P < .005$). No other categories of deviations, including donning and doffing PPE out of order, not performing hand hygiene, or improper gown use during donning (for example, not using the thumb loops on the gown or not tying the gown) were associated with detection of fluorescence. Types of protocol deviations included in the "improper gown use during donning," "gown doffing deviation," and "gloves or hands doffing deviation" are listed in eTables 1 through 3 (available online at the end of this article).

DISCUSSION

To our knowledge, this is the first study published in which DHCPs' practical use of PPE was assessed, particularly in the context of the COVID-19 pandemic. Although DHCP used PPE before the pandemic, some DHCP have increased their use of PPE or begun using types of PPE not used on a regular basis previously.[12-15] When used correctly, PPE is a vital tool that DHCP can use to protect themselves against exposure to SARS-CoV-2 and other pathogens, in both clinic and

Table 3. Percentage of donning and doffing steps with 1 or more protocol deviations.

STEP OR PPE* ITEM†	STEPS WITH PROTOCOL DEVIATION, NO. (%)
Donning	
Hand hygiene (n = 82)	54 (66)
Gown (n = 70)	44 (63)
Mask (n = 70)	40 (57)
Face shield or goggles (n = 78)	38 (49)
Gloves (n = 73)	32 (44)
Other‡ (n = 26)	6 (23)
Doffing	
Hand hygiene (n = 78)	61 (78)
Gown (n = 70)	42 (60)
Face shield or goggles (n = 65)	34 (52)
Other‡ (n = 21)	5 (24)
Mask (n = 70)	15 (21)
Gloves (n = 76)	14 (18)

* PPE: Personal protective equipment. † n: Number of observations. Total number of observations may be greater or less than the number of participants (n = 70) because some dental health care personnel (DHCP) donned and doffed multiple items (for example, 2 pairs of gloves) and some PPE items were not used by all DHCP (for example, eye protection). Some DHCP also donned and doffed more than 1 type of other PPE item. Some DHCP performed hand hygiene more than the prescribed number of times as per Centers for Disease Control and Prevention guidance; this was not considered a deviation. ‡ Other PPE items donned and doffed included loupes (n = 16), safety glasses (n = 12), head covering or scarf (n = 6), jacket (n = 4), laboratory coat (n = 2), regular glasses (n = 2), and earpiece (n = 1).

hospital settings.[16-18] In the dental literature, Ionescu and colleagues[19] performed a laboratory simulation during common dental practices and found that all PPE, regardless of type of mask or face shield used, reduced viral loads on the face (that is, mouth, mask, and forehead) substantially. In addition to simply using enhanced PPE, however, DHCP must be able to don and doff the PPE correctly to prevent self-contamination with pathogens. In published studies on PPE use in the medical setting, researchers have provided data on knowledge gaps, opportunities for donning and doffing process improvement, and the effect of interventions, such as education or training, on medical health care personnel's ability to use PPE[7,20]; however, comparable studies among DHCP are lacking.

There is a need for PPE education that targets DHCP specifically. Knowledge of the proper steps for donning and doffing PPE may be limited among DHCP,[21] and some investigators have found that DHCP perceived a need to update their knowledge of infection control practices and have better guidance on how to protect themselves from exposure to pathogens such as SARS-CoV-2.[22-24] In addition, the CDC's PPE donning and doffing instructions do not account for specialty equipment worn during oral health care, such as loupes or microscopes.[8] Some protocol deviations observed during our study included allowing loupes to rest on a contaminated gown or touching loupes with potentially contaminated hands. Because loupes are expensive, reused among patients, and difficult to disinfect, guidance regarding the best way to don and doff them without contamination would be valuable. Professional guidance, educational materials, and training interventions targeted specifically toward dentistry are needed and could have a substantial and positive impact on DHCP.

Our results suggest that 1 component of PPE that is problematic for DHCP is disposable gown use. Overall, 63% of DHCP made at least 1 protocol deviation when donning the gown and 60% of DHCP made at least 1 protocol deviation when doffing the gown, although many of these deviations were donning or doffing the gown out of order. Other common deviations included not using the opening for the head, not tying the gown, not using the thumb loops, or putting the gown over the gloves instead of vice versa. During doffing, many DHCP struggled to remove or dispose of the gown without contaminating their hands, arms, or scrubs. Our results indicate that donning and doffing out of order may not be as important for self-contamination risk as being able to don and

Table 4. Factors associated with detection of fluorescence.

VARIABLE	FLUORESCENCE DETECTED	NO FLUORESCENCE DETECTED	ODDS RATIO (95% CI)	*P* VALUE
Female, No. (%)	37 (77)	18 (81)	0.75 (0.21 to 2.68)	.76
Type of Dental Health Care Personnel, No. (%)				
Dentist or pediatric dentist	11 (23)	8 (36)	[Reference]	Not applicable
Dental hygienist, dental assistant, or other	28 (58)	11 (50)	1.85 (0.59 to 5.83)	.29
Endodontist, periodontist, or orthodontist	9 (19)	3 (14)	2.18 (0.44 to 10.73)	.34
Years of Experience,* Median (Range)	5 (0-45)	4.5 (0-36)	Not applicable	.93†
Any Prior PPE‡ Training, No. (%)	42 (88)	18 (82)	1.56 (0.39 to 6.19)	.71
Total No. of Donning Deviations, Median (Range)	3 (1-9)	3 (1-6)	Not applicable	.06
Total No. of Doffing Deviations, Median (Range)	3 (1-7)	2 (1-6)	Not applicable	.60
Total No. of Deviations, Donning and Doffing Combined, Median (Range)	6 (3-16)	5 (2-10)	Not applicable	.12†
Total No. of Deviations, Excluding Donning Out of Order and Not Performing Hand Hygiene During Donning, Median (Range)	5 (0-14)	3 (0-8)	Not applicable	.03†
Categories of Protocol Deviations, No. (%)				
Donned PPE out of order (any step)	35 (73)	18 (82)	0.60 (0.17 to 2.10)	.53
Doffed PPE out of order (any step)	25 (52)	11 (50)	1.09 (0.40 to 2.98)	.87
Improper gown use during donning	30 (63)	11 (50)	1.67 (0.60 to 4.62)	.32
Gown doffing deviation§	29 (60)	5 (23)	5.19 (1.64 to 16.44)	.005
Gloves or hands doffing deviation§	17 (35)	8 (36)	0.96 (0.34 to 2.75)	.94
Did not perform hand hygiene during donning	37 (77)	11 (50)	3.36 (1.15 to 9.84)	.02
Did not perform hand hygiene during doffing	37 (77)	14 (64)	1.92 (0.64 to 5.77)	.24
Did not perform hand hygiene during either donning or doffing	30 (63)	10 (46)	2.00 (0.72 to 5.56)	.18

* Data missing for 3 participants. † Mann-Whitney *U* test. ‡ PPE: Personal protective equipment. § Excludes protocol deviations for doffing out of order.

doff properly. However, other gown doffing deviations, excluding doffing out of order, were significantly associated with detection of fluorescence on DHCP's hands, arms, scrubs, or other body sites. These results are consistent with a previous study of PPE use in medical health care personnel, in which gown or apron removal was the doffing step in which the greatest number of participants committed at least 1 protocol deviation.[7] Researchers from other studies have also noted challenges and protocol deviations associated with doffing gowns.[25,26]

Hand hygiene protocol deviations (predominantly lack of washing hands) in our study were common, with 77% of DHCP having a hand hygiene protocol deviation during donning and 84% during doffing. This finding may not reflect actual hand hygiene rates during clinical care; instead, participants may have been unaware that they were expected to perform hand hygiene during our observations and focused on the physical PPE (that is, masks, gowns, gloves, and eye protection) instead. Regardless, the hand hygiene compliance rates we observed in our study are comparable

with a 2022 review of hand hygiene studies in hospital settings, in which most researchers found compliance to be in the range of 60% to 70%.[27] Comparable data among DHCP, although limited, suggest that hand hygiene compliance is similarly suboptimal; for example, Mutters and colleagues[28] found that only 7% through 39% of DHCP performed adequate hand hygiene after doffing gloves. Improving hand hygiene compliance remains an ongoing challenge for both health care and oral health care facilities.

We did not find hand hygiene protocol deviations during doffing to be associated with detection of fluorescence. This finding should be interpreted with caution. The fluorescent marker used in this study is only a surrogate and might not replicate pathogen transmission dynamics exactly. Our internal testing with the fluorescent marker indicated that it was easier to remove from hands with soap and water than with alcohol-based hand sanitizer (data not shown). Some participants in our study who performed hand hygiene with the alcohol-based hand sanitizer provided still had fluorescence detected on their hands. Regardless, the frequent transfer of fluorescence to DHCP's hands served as a visual reminder of the importance of hand hygiene.

There are several limitations to our study. All observations were performed under experimental conditions and not real-world observations during clinical care. Participating DHCP may have changed their usual behavior or practices as a result of being recorded and assessed. However, similar rates of protocol deviations were documented in a previous study of PPE donning and doffing among hospital-based health care personnel,[7] which suggests that the need for improved PPE use is consistent among health care professionals. DHCP were asked to use the PPE that our study team provided; with PPE shortages due to COVID-19, we did not want to ask participating clinics to provide their own PPE items for study use. DHCP may have had fewer donning and doffing deviations if they were using the style and types of PPE to which they were accustomed; however, the PPE provided for this study came from common commercial vendors and are standard PPE used commonly in health care settings. The sample size was relatively small, and larger studies are required to confirm our observations. A future study in which investigators evaluate donning and doffing deviations before and after specific education in PPE use would also help identify aspects of the donning and doffing process that could benefit from additional explanation or emphasis during training.

The COVID-19 pandemic continues to affect both medical health care personnel and DHCP. Although COVID-19 was the impetus behind many infection prevention initiatives, it is important to remember that improved infection prevention practices can prevent transmission of many other pathogens as well, such as influenza, other respiratory viruses, and multidrug-resistant organisms (for example, methicillin-resistant *S aureus*). PPE is an important tool that, when used properly, can help protect health care providers from exposure to pathogens and improve patient safety. Oral health care providers are frontline workers with increased risk of exposure to SARS-CoV-2, influenza, and other pathogens, and more data are needed on how best to educate them in PPE use to protect themselves and their patients.

CONCLUSIONS

DHCP protocol deviations and self-contamination were common with both donning and doffing PPE. Particular areas for improvement include hand hygiene and use of disposable gowns. PPE guidance specific to dentistry may be beneficial to DHCP. ■

SUPPLEMENTAL DATA

Supplemental data related to this article can be found at: https://doi.org/10.1016/j.adaj.2022.08.004.

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1. COVID-19 hazard recognition. Occupational Safety and Health Administration. Accessed October 14, 2021. https://www.osha.gov/coronavirus/hazards

2. Baek YS, Baek SH, Yoo YJ. Higher nasal carriage rate of methicillin-resistant *Staphylococcus aureus* among dental students who have clinical experience. *JADA*. 2016;147(5):348-353.

3. Laheij AM, Kistler JO, Belibasakis GN, Välimaa H, de Soet JJ. Healthcare-associated viral and bacterial infections in dentistry. *J Oral Microbiol*. 2012;4(1).

4. Dentistry workers and employers. Occupational Safety and Health Administration. Accessed September 28, 2021. https://www.osha.gov/coronavirus/control-prevention/dentistry

5. Interim Infection Prevention and Control Recommendations for Healthcare Personnel During the Coronavirus Disease 2019 (COVID-19) Pandemic. Centers for Disease Control and Prevention. Updated February 2, 2022. Accessed September 14, 2022. https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html

6. Return to Work Interim Guidance Toolkit. American Dental Association. Updated March 30, 2021. Accessed September 28, 2021. https://success.ada.org/~/media/CPS/Files/Open%20Files/ADA_Return_to_Work_Toolkit.pdf

7. Kwon JH, Burnham CD, Reske KA, et al. Assessment of healthcare worker protocol deviations and self-contamination during personal protective equipment donning and doffing. *Infect Control Hosp Epidemiol*. 2017;38(9):1077-1083.

8. Using personal protective equipment (PPE). Centers for Disease Control and Prevention. Updated August 19, 2020. Accessed September 28, 2021. https://www.cdc.gov/coronavirus/2019-ncov/hcp/using-ppe.html

9. Sequence for putting on personal protective equipment. Centers for Disease Control and Prevention. Accessed August 29, 2022. https://www.cdc.gov/hai/pdfs/ppe/ppe-sequence.pdf

10. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research Electronic Data Capture (REDCap): a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381.

11. Harris PA, Taylor R, Minor BL, et al.; on behalf of the REDCap Consortium. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208.

12. Amato A, Caggiano M, Amato M, Moccia G, Capunzo M, De Caro F. Infection control in dental practice during the COVID-19 pandemic. *Int J Environ Res Public Health*. 2020;17(13):4769.

13. Araujo MWB, Estrich CG, Mikkelsen M, et al. COVID-2019 among dentists in the United States: a 6-month longitudinal report of accumulative prevalence and incidence. *JADA*. 2021;152(6):425-433.

14. Carvalho JC, Declerck D, Jacquet W, Bottenberg P. Dentist related factors associated with implementation of COVID-19 protective measures: a national survey. *Int J Environ Res Public Health*. 2021;18(16):8381.

15. Estrich CG, Mikkelsen M, Morrissey R, et al. Estimating COVID-19 prevalence and infection control practices among US dentists. *JADA*. 2020;151(11):815-824.

16. Interim Infection Prevention and Control Recommendations for Healthcare Personnel During the Coronavirus Disease 2019 (COVID-19) Pandemic. Updated September 10, 2021. Accessed October 11, 2021. https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html

17. Tian C, Lovrics O, Vaisman A, et al. Risk factors and protective measures for healthcare worker infection during highly infectious viral respiratory epidemics: a systematic review and meta-analysis. *Infect Cont Hosp Epidemiol*. 2022;43(5):639-650.

18. Tian Z, Stedman M, Whyte M, Anderson SG, Thomson G, Heald A. Personal protective equipment (PPE) and infection among healthcare workers: what is the evidence? *Int J Clin Pract*. 2020;74(11):e13617.

19. Ionescu AC, Brambilla E, Manzoli L, Orsini G, Gentili V, Rizzo R. Efficacy of personal protective equipment against coronavirus transmission via dental handpieces. *JADA*. 2021;152(8):631-640.

20. Nayahangan LJ, Konge L, Russell L, Andersen S. Training and education of healthcare workers during viral epidemics: a systematic review. *BMJ Open*. 2021;11(5):e04411.

21. Bains VK, Bains R, Gupta V, Salaria SK. Knowledge of COVID-19 and its implications in dental treatment, and practices of personal protective equipment among dentists: a survey-based assessment. *J Educ Health Promot*. 2021;10:79.

22. Sánchez-Pérez L, de Antuñano DS, Perea-Pérez B, Labajo-González E, Acosta-Gio AE. Dentists' perceptions of their SARS-CoV-2 risk and infection control needs. *Int Dent J*. 2022;72(2):216-222.

23. Plessas A, Paisi M, Baines R, et al. Frontline experiences and perceptions of urgent dental care centre staff in England during the COVID-19 pandemic: a qualitative study. Published online September 6, 2021. *Br Dent J*. http://doi.org/10.1038/s41415-021-3375-3

24. Scully AC, Joshi AP, Rector JM, Eckert GJ. Willingness and ability of oral health care workers to work during the COVID-19 pandemic. *JADA*. 2021;152(10):791-799.

25. Phan LT, Maita D, Mortiz DC, et al.; for the CDC Prevention Epicenters Program. Personal protective equipment doffing practices of healthcare workers. *J Occup Environ Hyg*. 2019;16(8):575-581.

26. Okamoto K, Rhee Y, Schoeny M, et al.; for the Centers for Disease Control and Prevention Epicenters Program. Impact of doffing errors on healthcare worker self-contamination when caring for patients on contact precautions. *Infect Control Hosp Epidemiol*. 2019;40(5):559-565.

27. Mouajou V, Adams K, DeLisle G, Quach C. Hand hygiene compliance in the prevention of hospital acquired infections: a systematic review. *J Hosp Infect*. 2022;119:33-48.

28. Mutters NT, Hägele U, Hagenfeld D, Hellwig E, Frank U. Compliance with infection control practices in an university hospital dental clinic. *GMS Hyg Infect Control*. 2014;9(3):Doc18.

eTable 1. Deviations included under the category of improper gown use during donning.

DEVIATION	NO.
Did Not Use Thumb Loops on Gown	12
Did Not Tie Gown	8
Had to Be Prompted to Use Gown	8
Did Not Pull Gloves Over Wrists or Sleeves	6
Did Not Use Neck Opening on Gown	4
Donned Gown Over Gloves	2
Donned Gown Backwards	1

eTable 2. Deviations included under the category of gown doffing deviations.

DEVIATION	NO.
Touched Front or Sides of Gown With Bare Hands	16
Gown Touched Arms or Scrubs While Doffing	7
Touched Inside of Gown With Gloved Hands	4
Let Equipment* Rest on Contaminated Gown	3
Exposed Skin on Wrists While Doffing	2
Tore Thumb Loops	1
Pulled Gown Over Head	1

* Earpiece or loupes.

eTable 3. Deviations included under the category of gloves and hands doffing deviation.

DEVIATION*	NO.
Touched Face Shield With Contaminated Hands	10
Touched Face Mask With Contaminated Hands	10
Touched Loupes With Contaminated Hands	2
Touched Outside of Gloves With Bare Hands	2
Touched Gown With Bare Hands While Doffing Gloves	2
Touched Other Personal Protective Equipment (Jacket, Head Scarf) With Contaminated Hands	2
Glove Got Stuck in Arm of Gown During Doffing	1
Shook Wet Gloved Hands	1

* Some participants had more than 1 glove or hand doffing deviation.