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Evaluation of Comprehensive COVID-19 Testing Program Outcomes in a US Dental Clinical Care Academic Setting

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Abstract

IMPORTANCE Although many academic institutions have implemented infection control and prevention protocols, including regular asymptomatic self-testing, in response to the COVID-19 pandemic, the outcomes of mandatory surveillance testing programs at academic dental institutions that offer direct patient-facing clinical care has not yet been reported.

OBJECTIVE To report the findings of a comprehensive surveillance COVID-19 testing program at an academic dental institution by assessing SARS-CoV-2 positivity rates and the potential association of test positivity with individual-level characteristics such as age, sex, and role.

DESIGN, SETTING, AND PARTICIPANTS A retrospective cohort study was conducted using SARS-CoV-2 self-testing data from a mandatory surveillance program at the Harvard School of Dental Medicine. Test results obtained between August 24, 2020, and February 28, 2022, from students, faculty, and staff members were analyzed. Testing cadence varied from 1 to 3 times per week depending on risk status. The association of individual characteristics with test positivity was evaluated with univariate analyses and a bayesian multilevel logistic regression model.

EXPOSURES Age by decade, sex, and role or position category (staff members, faculty, and students stratified by their involvement in clinical care activities), testing cadence, and testing date.

MAIN OUTCOMES AND MEASURES Positive results from SARS-CoV-2 real-time reverse transcription–polymerase chain reaction self-tests were assessed.

RESULTS Of the 390 study participants, 210 (53.8%) were women. Participants were grouped by age as follows: 20 to 29 years (190 [48.7%]), 30 to 39 years (88 [22.6%]), 40 to 49 years (44 [11.3%]), 50 to 59 years (42 [10.8%]), and 60 years or older (26 [6.7%]). Test results demonstrated an overall 0.27% positivity rate (61 test-positive cases), with a peak weekly positivity rate of 5.12% in the first week of January 2022. The mean (SD) test positivity rate among those involved in clinical activities was 0.25% (0.04) compared with 0.36% (0.09) among nonclinical participants. When adjusting for all considered covariates, test positivity was significantly associated with testing frequency (3 times vs 1 time per week: odds ratio [OR], 1.51 [95% credible interval (CrI), 1.07-3.69]) and timing of the test (after vs during the Alpha wave: OR, 0.33 [95% CrI, 0.11-0.88]; and Omicron vs Alpha: OR, 11.59 [95% CrI, 6.49-22.21]) but not with individual characteristics (age, sex, and role).

CONCLUSIONS AND RELEVANCE These findings suggest that implementing an adaptive testing cadence based on the risk status of individuals may be effective in reducing the risk of SARS-CoV-2 infection within an institution. In this study, involvement in clinical activities did not pose additional risk of SARS-CoV-2 infection compared with other in-person activities in the presence of these control measures.

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Key Points

Question Are individual characteristics associated with SARS-CoV-2 test positivity rates of a comprehensive mandatory surveillance COVID-19 testing program in a US dental clinical care academic setting?

Findings In this cohort study with 390 participants in clinical and nonclinical roles, the overall test positivity rate was 0.27%; the mean test positivity rate was 0.25% among those involved in patient-facing clinical activities compared with 0.36% among nonclinical participants. Test positivity was significantly associated with testing cadence but not with individual characteristics such as age, sex, and role.

Meaning These findings suggest that involvement in patient-facing dental clinical activities did not pose additional risk of SARS-CoV-2 infection compared with other in-person activities in the presence of intensive control measures.

+ Supplemental content

Author affiliations and article information are listed at the end of this article.

Introduction

The 2020 declaration of COVID-19 as a pandemic resulted in a global upheaval that caused the closure of businesses and academic institutions. In dental medicine, SARS-CoV-2 infection is a major concern because of the clinician's close proximity to the patient's oral cavity and the production of aerosols and droplets during dental procedures.[1-3] The pandemic disrupted not only clinical care but also the didactic and research components of academic dental institutions. Although didactic content could be taught remotely using online platforms, preclinical activities requiring manikins were delayed. Research activities were also halted, resulting in great time and financial loss.[4,5]

In March 2020, Meng et al[6] introduced essential knowledge about COVID-19 in dental care settings and provided recommendations for both dental practices and education. Since then, academic dental institutions have moved forward to reestablish in-person activities as understanding of SARS-CoV-2 transmission and testing continues to improve. Because of the high percentage of asymptomatic SARS-CoV-2 infections and their potential transmission risk,[7] dental schools have applied public and local government guidelines, improved accessibility, assessed testing feasibility, and considered current epidemiological data to ensure faculty, staff, student, and patient safety. Furthermore, guidance on reopening institutions of higher education has helped mitigate the spread of COVID-19 on campus.[8,9]

Many institutions have incorporated reverse transcription–polymerase chain reaction (RT-PCR) testing at varying frequencies for asymptomatic surveillance of their community. Surveillance testing within institutions can be used as a tool in controlling the spread of COVID-19.[10-12] In addition, surveillance testing enables early identification of individuals who may or may not be symptomatic and helps prevent the spread of disease via contact tracing and isolation.[13,14]

The Harvard School of Dental Medicine (HSDM), the only school at Harvard University that offers direct patient care within university-operated facilities, used surveillance testing and contact tracing to safely reopen when in-person activities resumed in fall 2020. In this study, we present the results of Harvard's comprehensive, mandatory surveillance testing program by assessing HSDM positivity rates and the potential association of test positivity with individual-level characteristics (age, sex, and role), using deidentified data collected from 2020 through the beginning of 2022.

Methods

The Harvard Medical School Institutional Review Board deemed this cohort study exempt from review because it did not constitute human participant research; informed consent was thus waived. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Data Source and Study Population

Beginning in August 2020, recurring COVID-19 testing was required for all individuals authorized to live in dormitory-style, on-campus housing or to regularly work on campus at HSDM. Participants who submitted their test results to the surveillance program included students (predoctoral, graduate, and research), faculty, and staff members (**Figure 1**). Participant testing cadence varied from 1 to 3 times weekly, depending on the regularity of their presence on campus, vaccination status, and on-campus residential status. Individuals who were incompletely vaccinated were required to test more frequently, as were those who lived in on-campus residence halls. Those who were up to date on vaccination and who lived off campus had the lowest testing frequency. Individuals who worked remotely and did not attend campus consistently were not required to enter the campus for the sole purpose of testing. Those with close contacts to positive cases were advised to test more frequently during the subsequent week; if these individuals had a positive test result, contact tracing was performed. Before the major surge in cases associated with the Omicron variant, personalized outreach was practiced by a dedicated team of registered nurses who were trained in contact tracing at Harvard University Health Services. Personalized outreach included email and phone contact and followed best practices informed by the US Centers for Disease Control and Prevention (CDC) and state public health guidance.[15,16] When the volume of positive cases increased dramatically with Omicron, contact tracing focused largely on conducting automated outreach and addressing complex cases, whereas notification of close contacts became the responsibility of individuals with SARS-CoV-2 infection.

Results of real-time RT-PCR self-tests for SARS-CoV-2 infection were obtained from 391 individuals participating in the mandatory surveillance program at HSDM from August 24, 2020, through February 28, 2022. During the study period, 22 766 tests were processed; the results were obtained from the Broad Institute of MIT and Harvard and from the Harvard University Clinical Laboratory. Four records from 1 participant with failed or inconclusive test results were excluded from the analysis, resulting in 22 762 testing records from the 390 participants included in the study.

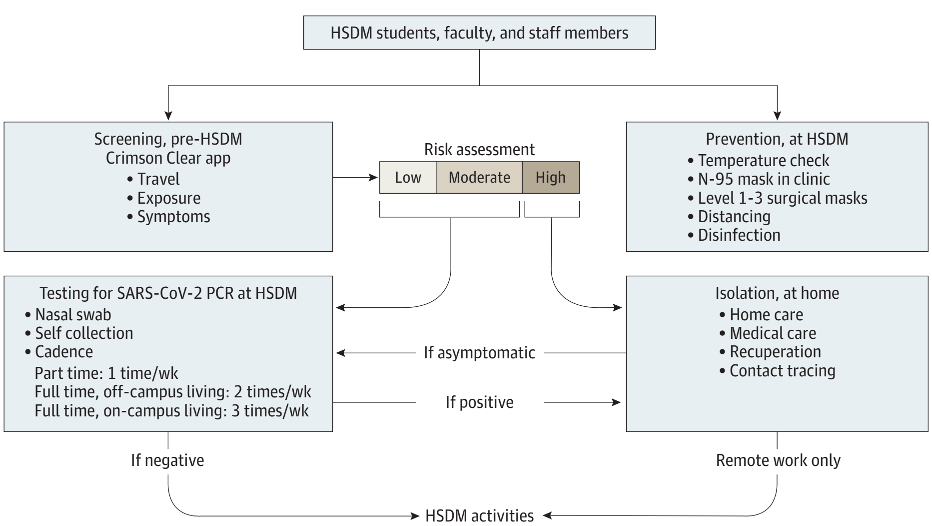
Statistical Analysis

Variables collected and derived for participant characteristics included age group by decade (20-29, 30-39, 40-49, 50-59, and ≥60 years), sex, role or position category (staff members, faculty, and students stratified by their involvement in clinical activities, referred to hereafter as role), testing frequency (number of tests completed per week), timing of the test (corresponding to different COVID-19 variant waves: August 2020 to February 2021 [Alpha], March 2021 to June 2021 [after Alpha], July 2021 to November 2021 [Delta], and December 2021 to February 2022 [Omicron]), and test date. For our exploratory analyses, test positivity rates in the studied cohort were measured as percentages of total testing records, using testing-level data. Test results that were canceled, failed, or inconclusive were excluded (547 of 22 762 records). If an individual tested positive multiple times in a 90-day period, only the first positive test was counted. We evaluated how positivity rates varied over time on a weekly basis.

To assess the crude association of individual characteristics (age, sex, and role) with test positivity, individual-level univariate analyses were conducted. For these analyses, results were aggregated to the individual level, with the outcome defined as having a positive test result at least once during the study period. The χ^2 or Fisher exact test was used depending on the number of observations in each category.

Using testing-level data, a bayesian multilevel logistic regression model was estimated to assess the association of individual characteristics with test positivity, adjusting for all available covariates such as age group, sex, role, testing frequency, and timing of the test. Testing frequency was included

Figure 1. Study Design



HSDM indicates Harvard School of Dental Medicine; PCR, polymerase chain reaction.

as a proxy to adjust for COVID-19 risk status. Timing of the test was included to account for SARS-CoV-2 infection rates over time and for different participation rates in the testing program across the study period (eFigure 1 in Supplement 1). The bayesian multilevel model was chosen because it is used (1) to aid in model convergence without needing to provide domain-specific prior information and (2) to account for repeated measures among participants by including a random effect at the individual level (eMethods in Supplement 1). Unadjusted and adjusted odds ratios (ORs) for the covariates considered are reported with 95% credible intervals (CrIs). Statistical significance for individual-level analysis was based on 2-sided *P* values ≤.05. For bayesian regression models, uncertainty in our estimates was represented using 95% CrIs computed from Markov chain Monte Carlo sampling. All analyses were performed with R, version 3.6.1 (R Foundation for Statistical Computing).

Results

Of the 390 participants, 210 (53.8%) were women and 180 (46.2%) were men. Participants were grouped by age decade as follows: 20 to 29 years (190 [48.7%]), 30 to 39 years (88 [22.6%]), 40 to 49 years (44 [11.3%]), 50 to 59 years (42 [10.8%]), and 60 years or older (26 [6.7%]). Deidentified SARS-CoV-2 self-test results from our study included 22 762 testing records obtained between August 2020 and February 2022. There were 299 (76.7%) and 91 (23.3%) participants involved in clinical and nonclinical activities, respectively (**Table 1**). Time of testing program entry varied during the study period; the number of participants who submitted testing samples peaked from January 2021 through May 2021, with the weekly number of participants varying from 249 to 299 (eFigure 1 in Supplement 1). The mean overall testing frequency was 1.32 times per week (95% CrI, 0.80-1.83 times per week; Table 1); among participants involved in clinical activities, the mean testing frequency was higher than for nonclinical participants, at 1.37 times per week compared with 1.15 times per week (eFigure 2 in Supplement 1). Students involved in patient care were tested most frequently, followed by clinical staff members.

During the study period, the overall test positivity rate was 0.27% (61 test-positive cases; eFigure 3 in Supplement 1) and the mean (SD) weekly positivity rate was 0.36% (0.85). The mean (SD) test-positive rate among participants involved in clinical activities was 0.25% (0.04) compared

Table 1. Study Population From August 2020 to February 2022

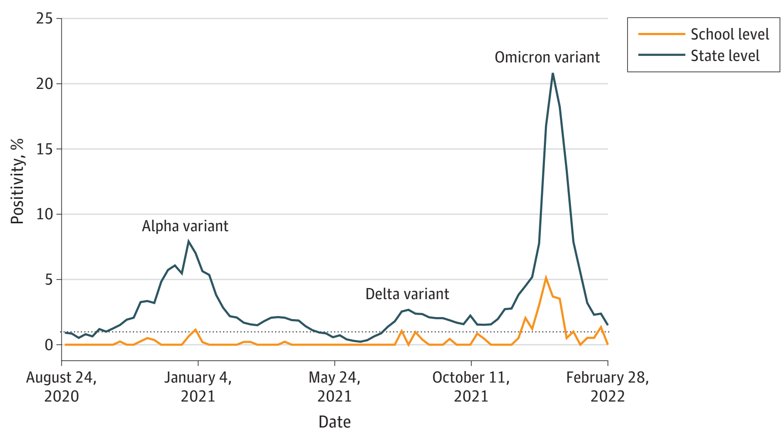
	No. of participants (%)[a]						
		Nonclinical (n = 91)			Clinical (n = 299)		
Characteristic	Total (N = 390)	Students (n = 25)	Faculty (n = 12)	Staff (n = 54)	Students (n = 214)	Faculty (n = 66)	Staff (n = 19)
Age, y							
20-29	190 (48.7)	7 (28.0)	0 (0.0)	9 (16.7)	170 (79.4)	3 (4.5)	1 (5.3)
30-39	88 (22.6)	18 (72.0)	0 (0.0)	10 (18.5)	42 (19.6)	13 (19.7)	5 (26.3)
40-49	44 (11.3)	0 (0.0)	4 (33.3)	17 (31.5)	2 (0.9)	19 (28.8)	2 (10.5)
50-59	42 (10.8)	0 (0.0)	4 (33.3)	12 (22.2)	0 (0.0)	17 (25.8)	9 (47.4)
≥60	26 (6.7)	0 (0.0)	4 (33.3)	6 (11.1)	0 (0.0)	14 (21.2)	2 (10.5)
Sex							
Male	180 (46.2)	17 (68.0)	5 (41.7)	21 (38.9)	92 (43.0)	41 (62.1)	4 (21.1)
Female	210 (53.8)	8 (32.0)	7 (58.3)	33 (61.1)	122 (57.0)	25 (37.9)	15 (78.9)
No. of tests per week, mean (95% CrI)	1.32 (0.80-1.83)	1.05 (0.88-1.22)	1.05 (0.77-1.33)	1.22 (0.75-1.68)	1.44 (0.96-1.91)	1.14 (0.77-1.51)	1.41 (1.10-1.72)
No. with a positive test result							
Ever	56 (14.4)	1 (4.0)	0 (0.0)	14 (25.9)	25 (11.7)	13 (19.7)	3 (15.8)
1 case	52 (13.3)	1 (4.0)	0 (0.0)	13 (24.1)	24 (11.2)	13 (19.7)	1 (5.3)
2 cases	3 (0.8)	0 (0.0)	0 (0.0)	1 (1.8)	1 (0.5)	0 (19.7)	1 (5.3)
3 cases	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.3)

[a] Percentages are reported as fractions of column totals.

with 0.36% (0.09) among nonclinical participants. The weekly test positivity rate peaked at 5.12% during the first week of January 2022, and the overall test positivity pattern was consistent with that observed in Massachusetts during different COVID-19 variant waves (**Figure 2**). At the individual level, 56 participants (14.4%) had at least 1 positive test result during the study period (Table 1) and 4 (1.0%) had more than 1 positive test result.

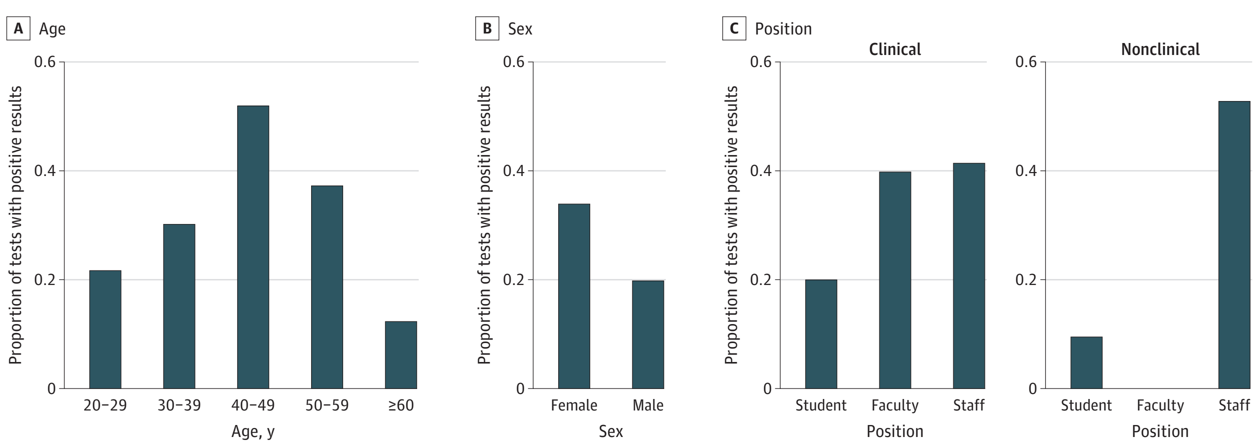
Test positivity rates varied by individual characteristics. Based on our univariate analyses at the individual level, role was significantly associated with positive test results (eFigure 4 in Supplement 1). Nonclinical staff members tested most often, with a positivity rate of 0.53% during the study period (**Figure 3**). When adjusting for all covariates considered in the bayesian multilevel logistic regression model, test positivity was significantly associated with testing frequency (number of tests per week determined based on individual risk status) and timing of the test (corresponding to COVID-19 waves) using test-level data (**Table 2**). The likelihood of testing positive increased significantly for individuals required to test 3 times per week (OR, 1.51 [95% CrI, 1.07-3.69]) compared with testing only once per week. Our regression results also showed that compared with August 2020 to February 2021 (Alpha), the likelihood of testing positive decreased significantly between March 2021 and June 2021 (after Alpha; OR, 0.33 [95% CrI, 0.11-0.88]) and increased between December 2021 and February 2022 (Omicron; OR, 11.59 [95% CrI, 6.49-22.21]). When the model was fully adjusted, other individual characteristics (age group, sex, and role) were no longer associated with test positivity.

Figure 2. Comparison of SARS-CoV-2 Test Positivity Rates Among the Harvard School of Dental Medicine and Massachusetts Populations



Weekly test positivity rates (for August 24, 2020, to February 28, 2022) were assessed. Alpha, Delta, and Omicron variant peaks are shown. Massachusetts data were obtained from the state COVID-19 interactive data dashboard.[17]

Figure 3. Percentage of SARS-CoV-2–Positive Test Results by Participant Characteristics, Including Age, Sex, and Role



Discussion

In this cohort study, the overall asymptomatic SARS-CoV-2 test positivity rate remained low at 0.27%. This finding suggests that the implemented infection control and prevention protocols were effective in reducing COVID-19 risk within a dental clinical care academic setting. We also observed that involvement in clinical activities did not seem to increase the risk of SARS-CoV-2 infection. Although individuals involved in clinical activities performed a higher number of tests per week on average, the test positivity rate remained lower than for nonclinical individuals, contributing to the safety of both patients and health care practitioners in clinical settings. In our adjusted regression model, individual characteristics were not significantly associated with positive test results, except for timing of the test and testing frequency, which was determined based on participants' on-campus presence regularity, vaccination status, and on-campus residential status. This finding signifies the importance of adaptive testing cadence when implementing large-scale surveillance testing programs at academic institutions.

Because oral health care practitioners work in close proximity to patients' mouth, nose, and throat, both patients and practitioners may be considered at high risk of SARS-CoV-2 infection. While dental care workers at HSDM used N95 masks and plexiglass shields, aerosol mitigation with aerosol-generating procedures, and physical distancing, the environment was considered safe and there were no documented cases of clinician-to-patient transmission (data not shown). Some dental procedures may lead to aerosol generation, further increasing transmission risk through direct inhalation or contact with contaminated surfaces.[18] Because of the unique nature of dental care settings and interventions, the World Health Organization (WHO) initially advised in August 2020

Table 2. Results of Bayesian Multilevel Logistic Regression Model

Characteristic	OR (95% CrI) Unadjusted	OR (95% CrI) Adjusted
Age, y		
20-29	1 [Reference]	1 [Reference]
30-39	1.58 (0.68-3.64)	1.27 (0.60-2.64)
40-49	3.02 (1.06-8.45)	1.28 (0.50-3.24)
50-59	1.73 (0.59-5.10)	0.85 (0.32-2.24)
≥60	0.59 (0.11-3.27)	0.43 (0.12-1.45)
Sex		
Female	1 [Reference]	1 [Reference]
Male	0.53 (0.27-1.06)	0.62 (0.34-1.14)
Role or position category		
Clinical		
Student	1 [Reference]	1 [Reference]
Faculty	1.72 (0.85-3.26)	1.72 (0.71-4.23)
Staff	1.97 (0.84-4.32)	2.01 (0.72-5.43)
Nonclinical		
Student	0.62 (0.20-1.69)	0.55 (0.18-1.58)
Faculty	0.49 (0.10-2.14)	0.50 (0.09-2.49)
Staff	2.03 (0.64-7.03)	2.12 (0.58-7.66)
No. of tests per week		
1	1 [Reference]	1 [Reference]
2	0.64 (0.33-1.28)	1.11 (0.62-1.91)
3	1.64 (1.21-5.64)[a]	1.51 (1.07-3.69)[a]
COVID-19 variant wave		
Alpha (August 2020 to February 2021)	1 [Reference]	1 [Reference]
After Alpha (March 2021 to June 2021)	0.22 (0.04-1.01)	0.33 (0.11-0.88)[a]
Delta (July 2021 to November 2021)	1.17 (0.47-2.93)	1.13 (0.47-2.54)
Omicron (December 2021 to February 2022)	15.35 (7.53-31.27)[a]	11.59 (6.49-22.21)[a]

Abbreviations: CrI, credible interval; OR, odds ratio.

[a] Significant results with 95% CrIs not containing 1.

that routine nonurgent oral health care be delayed until COVID-19 transmission rates were reduced from community transmission to cluster cases.[19] To protect patients and the dental care team on resumption of dental care, the CDC, the American Dental Association, the US Occupational Safety and Health Administration, and the WHO released infection prevention and control guidelines for providing the full range of dental care.[20-22] Safety of the dental office is a priority in dental clinical care academic settings. Implementation of comprehensive mandatory surveillance testing programs can help limit the spread of COVID-19 on campus when coupled with infection prevention and control guidelines. These programs also serve to create a sense of security for members of the academic, clinical, and patient care communities.[23]

In this study, the asymptomatic test positivity rate at HSDM was 0.27% among 390 students, faculty, and staff members from August 2020 through February 2022. However, a study of a SARS-CoV-2 surveillance testing program at the Georgia Institute of Technology (with 18 029 students, staff, and faculty) reported a mean asymptomatic test positivity rate of 0.84% during the 2020 fall semester.[24] The Duke University surveillance program (with 10 265 students) reported a weekly per capita positivity rate of 0.08% during fall 2020.[25] The results of surveillance testing programs at academic institutions varied widely, and these contrasting examples emphasize the need to assess the costs and benefits of implementing large-scale surveillance testing programs upon evaluating test sensitivity and retrospective serologic surveys.

We observed that higher testing frequency was associated with a higher test positivity rate. Testing frequency in our study was determined based on the risk status of individuals; to mitigate viral spread, a higher testing cadence was required for those at potentially increased risk of infection. This finding may seem contradictory to that of a previous modeling study that demonstrated no association between testing frequency and infection transmission.[26] Although this hypothetical modeling study evaluated the association of varying testing frequencies applied universally with the overall infection rates as a means of rapidly detecting positive cases, it is important to note that our study is limited to the results of the asymptomatic mandatory testing program at Harvard, which cannot capture the overall positive cases detected from contact tracing and symptomatic monitoring. As such, we recognize that our findings specifically highlight the need for adaptive testing cadence based on the individual level of risk rather than assessment of the effectiveness of testing cadence on overall infection rates. Having access to complete data on SARS-CoV-2 infection status, which include the overall positive cases from contact tracing and symptomatic monitoring within the institution, would allow us to accurately evaluate the effectiveness of the mandatory surveillance testing program, which would inform quality improvement in the interest of institutional safety amid a public health emergency.

Limitations

This study has some limitations. As with any observational study, there may be unmeasured variables that confound the association of individual covariates with positive test results, such as other sociodemographic (race and ethnicity and educational attainment) and regional characteristics that were found to be substantial predictors of SARS-CoV-2 test positivity from this single center investigation.[27] Additionally, because our data were collected from a single institution, the results may not be generalizable to other organizations implementing mandatory SARS-CoV-2 testing. Notwithstanding these limitations, the ability to better understand the interplay of a professional education program delivering clinical care and implications on COVID-19 transmission is a benefit of academic clinical settings.

Conclusions

Implementation of adaptive testing cadence based on the risk status of individuals may assist with timely detection of SARS-CoV-2 infection and thus reduce the risk of infection within dental clinical care academic settings. In this study, dental clinical care activities, including aerosol-generating procedures, did not pose additional risk of SARS-CoV-2 infection compared with other in-person activities in the presence of these control measures. These findings suggest that the cumulative effect of these measures was successful in reducing the risk of infection associated with patient care.

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Author Contributions: Drs Choi and Giannobile had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Drs Choi and Sima contributed equally to this work.

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REFERENCES

1. Elagib MFA, Baldo SMH, Tawfig A, Alqarni MA, Ghandour IA, Idris AM. Knowledge, attitude, and practice regarding infection control measures among dental students during COVID-19 pandemic. *Arch Environ Occup Health*. 2022;77(6):455-467. doi:10.1080/19338244.2021.1931796

2. Bera R, Kalia P, Hiremath S, Jaiswal D. Knowledge, awareness, attitude and practice of dental practitioners regarding Covid-19 pandemic and infection control: a cross sectional study in Kolkata metropolitan region. *Rocz Panstw Zakl Hig*. 2021;72(1):95-101.

3. 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):E4769. doi:10.3390/ijerph17134769

4. Wu DT, Wu KY, Nguyen TT, Tran SD. The impact of COVID-19 on dental education in North America—where do we go next? *Eur J Dent Educ*. 2020;24(4):825-827. doi:10.1111/eje.12561

5. Iyer P, Aziz K, Ojcius DM. Impact of COVID-19 on dental education in the United States. *J Dent Educ*. 2020;84(6):718-722. doi:10.1002/jdd.12163

6. Meng L, Hua F, Bian Z. Coronavirus disease 2019 (COVID-19): emerging and future challenges for dental and oral medicine. *J Dent Res*. 2020;99(5):481-487. doi:10.1177/0022034520914246

7. Ma Q, Liu J, Liu Q, et al. Global percentage of asymptomatic SARS-CoV-2 infections among the tested population and individuals with confirmed COVID-19 diagnosis: a systematic review and meta-analysis. *JAMA Netw Open*. 2021;4(12):e2137257. doi:10.1001/jamanetworkopen.2021.37257

8. American Industrial Hygiene Association. Back to work safely: guidance for institutions of higher education. 2021. Accessed May 2, 2022. https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/BacktoWorkSafely/Back-to-Work-Safely-Guidance-for-Institutions-of-Higher-Education-Guidance-Document-2nd-edition.pdf

9. American College Health Association. Considerations for reopening institutions of higher education for the spring semester 2021. 2020. Accessed May 2, 2022. https://www.acha.org/documents/resources/guidelines/ACHA_Considerations_for_Reopening_IHEs_for_Spring_2021.pdf

10. Ibrahim NK. Epidemiologic surveillance for controlling Covid-19 pandemic: types, challenges and implications. *J Infect Public Health*. 2020;13(11):1630-1638. doi:10.1016/j.jiph.2020.07.019

11. Brook CE, Northrup GR, Ehrenberg AJ, Doudna JA,Boots M; IGI SARS-CoV-2 Testing Consortium. Optimizing COVID-19 control with asymptomatic surveillance testing in a university environment. *medRxiv*. Preprint posted online October 27, 2021. doi:10.1101/2020.11.12.20230870

12. World Health Organization. Surveillance strategies for COVID-19 human infection. 2020. Accessed April 30, 2022. https://www.who.int/docs/default-source/coronaviruse/risk-comms-updates/update-29-surveillance-strategies-for-covid-19-human-infection.pdf?sfvrsn=3c2cab92_2

13. Sheridan C. Coronavirus and the race to distribute reliable diagnostics. *Nat Biotechnol*. 2020;38(4):382-384. doi:10.1038/d41587-020-00002-2

14. Mercer TR, Salit M. Testing at scale during the COVID-19 pandemic. *Nat Rev Genet*. 2021;22(7):415-426. doi:10.1038/s41576-021-00360-w

15. US Centers for Disease Control and Prevention. Contact tracing for COVID-19. Updated February 10, 2022. Accessed April 2, 2022. https://www.cdc.gov/coronavirus/2019-ncov/php/contact-tracing/contact-tracing-plan/contact-tracing.html

16. Massachusetts Department of Public Health. COVID-19 Community Tracing Collaborative (CTC). Accessed November 11, 2021. https://www.mass.gov/info-details/covid-19-community-tracing-collaborative-ctc

17. Commonwealth of Massachusetts. COVID-19 Interactive Data Dashboard. 2022. Accessed May 23, 2022. https://www.mass.gov/info-details/covid-19-response-reporting#covid-19-interactive-data-dashboard-

18. US Centers for Disease Control and Prevention. Scientific brief: SARS-CoV-2 and potential airborne transmission. 2021. Accessed October 31, 2021. https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/sars-cov-2-transmission.html

19. World Health Organization. Considerations for the provision of essential oral health services in the context of COVID-19. 2020. Accessed November 3, 2021. https://www.who.int/publications/i/item/who-2019-nCoV-oral-health-2020.1

20. US Centers for Disease Control and Prevention. Infection prevention and control in dental settings. 2020. Accessed November 1, 2021. https://www.cdc.gov/oralhealth/infectioncontrol/index.html

21. World Health Organization. COVID-19: occupational health and safety for health workers: interim guidance. 2021. Accessed May 3, 2022. https://www.who.int/publications/i/item/WHO-2019-nCoV-HCW_advice-2021-1

22. American Dental Association. OSHA guidance summary: dentistry workers and employers. 2021. Accessed May 3, 2022. https://www.ada.org/-/media/project/ada-organization/ada/ada-org/files/resources/coronavirus/covid-19-safety-and-clinical-resources/osha_guidance_summary_dentistry_workers_and_employers.pdf?rev=3f5984028f70437eb03a5ca8d9404184&hash=B2FBC4F5C43C85C356634E01BC951D0C

23. Oster Y, Wolf DG, Olshtain-Pops K, Rotstein Z, Schwartz C, Benenson S. Proactive screening approach for SARS-CoV-2 among healthcare workers. *Clin Microbiol Infect*. 2021;27(1):155-156. doi:10.1016/j.cmi.2020.08.009

24. Gibson G, Weitz JS, Shannon MP, et al. Surveillance-to-diagnostic testing program for asymptomatic SARS-CoV-2 infections on a large, urban campus in fall 2020. *Epidemiology*. 2022;33(2):209-216. doi:10.1097/EDE.0000000000001448

25. Denny TN, Andrews L, Bonsignori M, et al. Implementation of a pooled surveillance testing program for asymptomatic SARS-CoV-2 infections on a college campus—Duke University, Durham, North Carolina, August 2–October 11, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(46):1743-1747. doi:10.15585/mmwr.mm6946e1

26. Paltiel AD, Zheng A, Walensky RP. Assessment of SARS-CoV-2 screening strategies to permit the safe reopening of college campuses in the United States. *JAMA Netw Open*. 2020;3(7):e2016818. doi:10.1001/jamanetworkopen.2020.16818

27. Parker DM, Bruckner T, Vieira VM, et al. Predictors of test positivity, mortality, and seropositivity during the early coronavirus disease epidemic, Orange County, California, USA. *Emerg Infect Dis*. 2021;27(10):2604-2618. doi:10.3201/eid2710.210103

SUPPLEMENT 1.

eMethods. Bayesian Modeling
eFigure 1. Number of Participants Submitting Testing Samples by Week
eFigure 2. Distribution of Testing Frequency by Role or Position Categories
eFigure 3. Characteristics of SARS-CoV-2 Testing Records
eFigure 4. Univariate Analyses at the Individual Level

SUPPLEMENT 2.

Data Sharing Statement

Original Contributions

Cover Story

COVID-19 among dentists in the United States

A 6-month longitudinal report of accumulative prevalence and incidence

Marcelo W.B. Araujo, DDS, MS, PhD; Cameron G. Estrich, MPH, PhD; Matthew Mikkelsen, MA; Rachel Morrissey, MPA; Brittany Harrison, MA; Maria L. Geisinger, DDS, MS; Effie Ioannidou, DDS, MDS; Marko Vujicic, PhD

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ABSTRACT

Background. In 2020, the Centers for Disease Control and Prevention and the American Dental Association released COVID-19 infection control interim guidance for US dentists, advising the use of optimal personal protection equipment during aerosol-generating procedures. The aim of this longitudinal study was to determine the cumulative prevalence and incidence rates of COVID-19 among dentists and to assess their level of engagement in specific infection control practices.

Methods. US dentists were invited to participate in a monthly web-based survey from June through November 2020. Approximately one-third of initial respondents (n = 785) participated in all 6 surveys, and they were asked about COVID-19 testing received, symptoms experienced, and infection prevention procedures followed in their primary practice.

Results. Over a 6-month period, the cumulative COVID-19 infection prevalence rate was 2.6%, representing 57 dentists who ever received a diagnosis of COVID-19. The incidence rates ranged from 0.2% through 1.1% each month. The proportion of dentists tested for COVID-19 increased over time, as did the rate of dentists performing aerosol-generating procedures. Enhanced infection prevention and control strategies in the dental practice were reported by nearly every participant monthly, and rates of personal protection equipment optimization, such as changing masks after each patient, dropped over time.

Conclusions. US dentists continue to show a high level of adherence to enhanced infection control procedures in response to the ongoing pandemic, resulting in low rates of cumulative prevalence of COVID-19. Dentists are showing adherence to a strict protocol for enhanced infection control, which should help protect their patients, their dental team members, and themselves.

Practical Implications. COVID-19 infections among practicing dentists will likely remain low if dentists continue to adhere to guidance.

Key Words. Severe acute respiratory syndrome; dentistry; infection control; aerosols; dental care.

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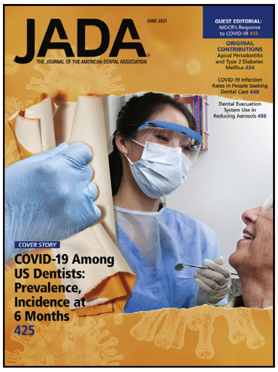

As of February 2021, severe acute respiratory syndrome coronavirus 2 (SARs-CoV-2) has infected tens of millions worldwide with severe cases resulting in hospitalization and death. SARS-CoV-2, the virus that causes COVID-19, is transmitted primarily through person-to-person contact, as well as via virus-containing droplets (5-12 μm) and aerosols ($\leq$ 5 μm). Susceptible people may become infected if virus-containing respiratory droplets or aerosols settle on their mucosa or are inhaled.[1] The scientific community has established that transmission of COVID-19 is linked to aerosol-generating procedures (AGPs) and that the total viral load to which the health care providers (HCPs) are exposed is the main risk factor for infection.[2] Therefore, both the Centers for Disease Control and Prevention (CDC) and World Health Organization have issued statements specific to AGPs and the need for the use of enhanced personal protective

This article has an accompanying online continuing education activity available at: http://jada.ada.org/ce/home.

equipment (PPE).[3,4] In 2020, a cross-sectional study published by our group reported that the prevalence of COVID-19 among US dentists was low, with a weighted estimated rate of 0.9% (95% CI, 0.5% to 1.5%).[5] The study's results showed that dentists following interim safety guidance were well prepared to resume their practice.[5]

In addition to our study,[5] there have been limited reports on rates of COVID-19 among dentists. One report evaluated safety practices in 3 specialty dental clinics in the New York, New York, area and observed 0 cases of COVID-19 among 2,810 patients, 2 dentists, and 3 registered dental hygienists during a 6-month period. The practices indicated enhanced use of PPE, increased measures to screen and protect patients seeking care, and assessment of infection risk factors.[6] Considering the infection rate in New York, New York, at the time, the authors concluded that oral health care can be safely provided as long as appropriate safety measures are followed.[6] Another report surveyed 454 members of the American Academy of Endodontics, finding a high rate of adherence to enhanced infection control measures, including the use of N95 respirator (also called an "N95 mask") by 83.1% of the participants.[7]

In the time after our initial study was deployed, the interim guidance for dental professionals from the American Dental Association (ADA) and CDC were revised on the basis of emerging scientific data. Most revisions addressed types of PPE for various procedure types, management of aerosols in the operatory area, and quarantine periods for dental HCPs exposed to COVID-19.[3,8] As of December 2020, the revised CDC interim recommendations mandated that dental HCPs wear N95 masks or those that offer an equivalent or higher level of protection, gowns or protective clothing, and gloves and eye protection (goggles or full face shields) during AGPs and in areas with moderate to substantial community transmission of COVID-19 during AGPs.[9]

Although cross-sectional studies offer a snapshot of infection rates in a given population, there is a paucity of widespread longitudinal evidence of the safety levels and rates of infection among dentists and other HCP. Our 6-month longitudinal study aimed to

- determine the cumulative prevalence rate of COVID-19 among dentists;
- calculate the monthly incidence rate for the same population over the course of the study;
- assess the level of engagement in specific infection control practices among dentists over a 6-month period.

METHODS

We administered a novel web-based cross-sectional survey using Qualtrics from June 8 through November 13, 2020. Dentists were eligible to participate if they held a license to practice dentistry in the United States, were in private practice or public health, and indicated a willingness to participate in the previous ADA-generated survey related to COVID-19. The protocol and survey were approved by the ADA Institutional Review Board and registered at ClinicalTrials.gov (NCT04423770). Details of the study population and questionnaire are described in our previous publication.[5] We made several changes to the questionnaire after the first survey on June 8, 2020, which are detailed in the Supplemental File. All participants signed an electronic informed consent before starting the survey.

We ascertained COVID-19 infection via self-reported date, type, and result of COVID-19 test (confirmed case) or, if not tested, the date an HCP told the respondent he or she had a probable COVID-19 infection (probable case). Each month, we considered those who reported a COVID-19 positive test or diagnosis who had not previously received a diagnosis of COVID-19 as newly infected. We calculated monthly incidence as the number of new confirmed or probable cases that month divided by the total number of dentists responding to the survey that month. The date a respondent was tested or received a diagnosis was missing for 22.0% of cases, so we used self-reported dates only to verify in which month a case should be counted. In no instance did the reported date not match the month in which it was counted. We also calculated the positivity rate as the number of confirmed cases over the total number of those tested that month. Respondents reported which PPE they used and how often when treating patients in the prior month as never, sometimes, or always. We used the CDC interim guidance document to categorize PPE use.[3]

We conducted all statistical analysis in Stata Version 13.0 (StataCorp). For COVID-19 testing results, we performed statistical weighting using linearization variance estimation so that the sample appropriately represented licensed US dentists in private practice or public health by age group and US Census Bureau division. We used single and multivariable multilevel regression models (logistic for binary outcomes, ordered logistic for ordinal outcomes), with survey results nested within each

ABBREVIATION KEY

ADA: American Dental Association.
AGP: Aerosol-generating procedure.
CDC: Centers for Disease Control and Prevention.
HCP: Health care provider.
PPE: Personal protective equipment.
SARs-CoV-2: Severe acute respiratory syndrome coronavirus 2.

respondent to account for the same respondents answering surveys over time. We weighted COVID-19 incidence and used linearization variance so that the estimated incidence more accurately represented licensed US dentists in private practice or public health by age group and US Census Bureau division. We determined the weights on the basis of the ADA master file of all US dentists, as previously described.[5]

RESULTS

A total of 2,196 US dentists participated in our 6-month longitudinal study from June 8 through November 13, 2020. The initial response rate was 40.1% in the first month. A decreasing number of the initial respondents continued to participate in the survey, such that 1,291 (58.8% of those who participated in the first month) participated in the final month, and a total of 785 (35.7% of initial respondents) participated in all 6 surveys. One participant who completed the initial survey 3 days after the study period ended had been excluded from the previously reported cross-sectional results[5] but was included in this analysis.

The median age of responding dentists was 52.6 years, and most (1,300 [59.2%]) were male (Table). Overall, most respondents were non-Hispanic White (1,673 [76.1%]), in private practice (2,081 [94.8%]), and general dentists (1,802 [82.1%]). Participants with missing demographic and practice information in the first survey were asked again the following month, allowing for lower proportions of missing data in this study than our initial report.[5] When exploring factors potentially related to participation rates, we observed that age, sex, race and ethnicity, region, and dental practice type were not associated with continued participation ($P > .3$). Among the respondents, 536 (an estimated 24.4%) had at least 1 medical condition associated with higher risk of developing severe illness from COVID-19, most commonly asthma (160 [7.3%]) and obesity (166 [7.6%]).

To identify potential sources of infection, we asked dentists about their activities outside of their clinical practices. In the first month, 103 (4.7%) dentists reported no in-person contact (that is, interaction) with anyone outside their household in the month before answering the survey. This rate was significantly lower ($P < .01$) in all subsequent months (Figure 1). In-person contact in health care practice or social setting outside the household in the prior month were not significantly associated with participant age group or sex ($P > .6$) but was significantly associated with location. Specifically, over the course of the study, dentists in the Pacific region and Puerto Rico had the lowest overall rates of in-person contact ($P < .01$) compared with other regions of the nation. Rates of in-person contact with people outside of the household in the prior month did not significantly change in most regions over time ($P > .05$) but increased significantly over the study period in the Middle Atlantic region and Puerto Rico ($P < .05$).

Throughout the study period, a minority of participants reported contact with someone with a suspected or confirmed COVID-19 infection in the past month. The percentage reporting contact with someone with COVID-19 significantly increased over time, from 4.6% (n = 100) in the first survey to 16.1% (n = 208) in the final survey ($P < .01$). In total, contact with someone with a suspected or confirmed COVID-19 infection was reported 875 times among the 2,196 participants over the course of 6 months; 430 (49.1%) of those reports were because of contact with dental patients. Another 310 (35.4%) stated that within the past month a coworker had COVID-19. In the study period, the likely source of COVID-19 was identified via contact tracing by a health agency or clinic in only 23 cases among dentists; in 2 instances, the dental practice was identified as the likely infection source.

Each month, most participants indicated that they provided oral health care in the prior month, increasing significantly over time from 2,043 (93.0%) in the first survey to 1,266 (98.1%) in the sixth ($P < .01$). The rate of dentists performing AGPs increased from 92.8% (n = 1,893) in the first survey to 97.3% (n = 1,502) in the second survey and continued to rise over time to 98.4% (n = 1,246) by the end of the study period ($P < .01$). Over the period of our longitudinal study, the use of at least a surgical mask and eye protection while performing non-AGPs remained statistically stable, and similar results were observed for always wearing a N95 mask or equivalent and eye protection in the same month they performed AGPs ($P > .5$). We saw a statistically significant decline in dentists reporting sometimes or always wearing N95 or equivalent masks and eye protection during AGPs over time from 92.4% in the first survey to 88.0% in the final survey ($P < .01$) (Figure 2).

During the course of our study, the CDC encouraged PPE optimization strategies in instances of limited PPE supplies.[3] In the first month, only 355 (17.6%) dentists reported changing their masks

Table. Characteristics of the survey sample and comparison with all private practice or public health dentists licensed in United States.

CHARACTERISTIC	PROPORTION OF SAMPLE,* NO. (%)
Age Group†, y	
27-39	344 (15.7)
40-49	509 (23.2)
50-59	589 (26.8)
60-69	601 (27.4)
70-84	105 (4.8)
Missing	48 (2.2)
Race and Ethnicity	
Non-Hispanic White	1,673 (76.1)
Non-Hispanic Asian	168 (7.7)
Hispanic or Latino	186 (8.5)
Non-Hispanic Black	26 (1.2)
American Indian or Alaska Native	5 (0.2)
Native Hawaiian or Pacific Islander	4 (0.2)
Other or missing	134 (6.1)
Sex	
Male	1,300 (59.2)
Female	845 (38.5)
Prefer not to say or missing	51 (2.3)
Dental Practice Type†	
Private practice	2,081 (94.8)
Federally qualified health center	56 (2.6)
Nonfederally qualified health center	8 (0.4)
City or county health department	10 (0.5)
Missing	41 (1.9)
Practice Type†	
General dentist	1,802 (82.1)
Dental anesthesiology	2 (0.1)
Endodontics	34 (1.6)
Oral and maxillofacial pathology	1 (0.05)
Oral and maxillofacial surgery	58 (2.6)
Oral medicine	2 (0.1)
Orofacial pain	2 (0.1)
Orthodontics and dentofacial orthopedics	44 (2.0)
Pediatric dentistry	147 (6.7)
Periodontics	50 (2.3)
Prosthodontics	14 (0.6)
Missing	40 (1.8)
Census Bureau Division†	
New England	143 (6.5)
Middle Atlantic	269 (12.3)
East North Central	426 (19.4)

* N = 2,196. † Percentages may not total 100 due to rounding.

Table. Continued

CHARACTERISTIC	PROPORTION OF SAMPLE,* NO. (%)
West North Central	226 (10.3)
South Atlantic	339 (15.4)
East South Central	98 (4.5)
West South Central	178 (8.1)
Mountain	149 (6.8)
Pacific	344 (15.7)
Territories	24 (1.1)

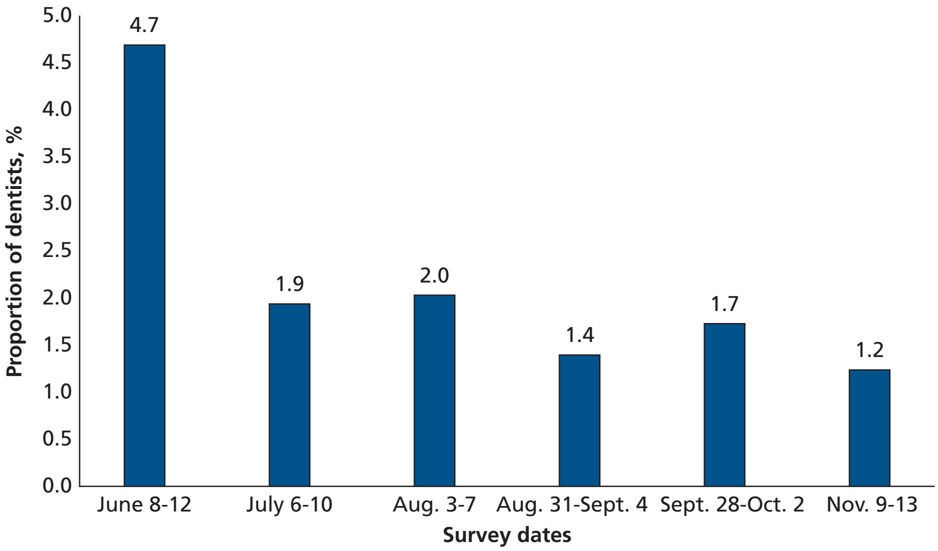

Figure 1. Dentists reporting no in-person contact outside the home, by month and US Census Bureau division (9,320 observations).

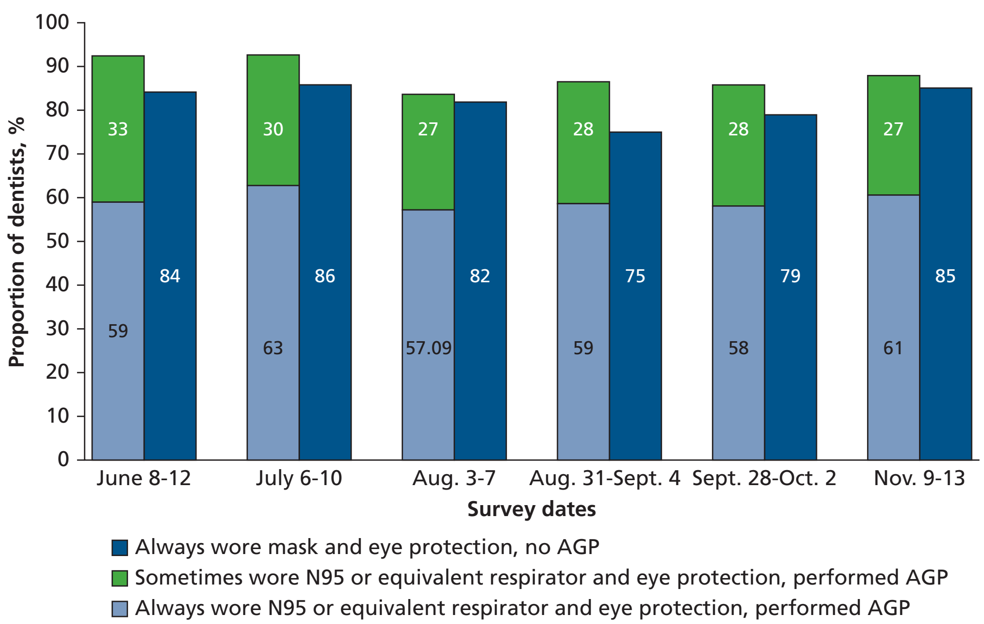

Figure 2. Personal protective equipment use according to Centers for Disease Control and Prevention interim guidelines for dental settings by month (8,966 observations, restricted to those practicing dentistry each month). AGP: Aerosol-generating procedure.

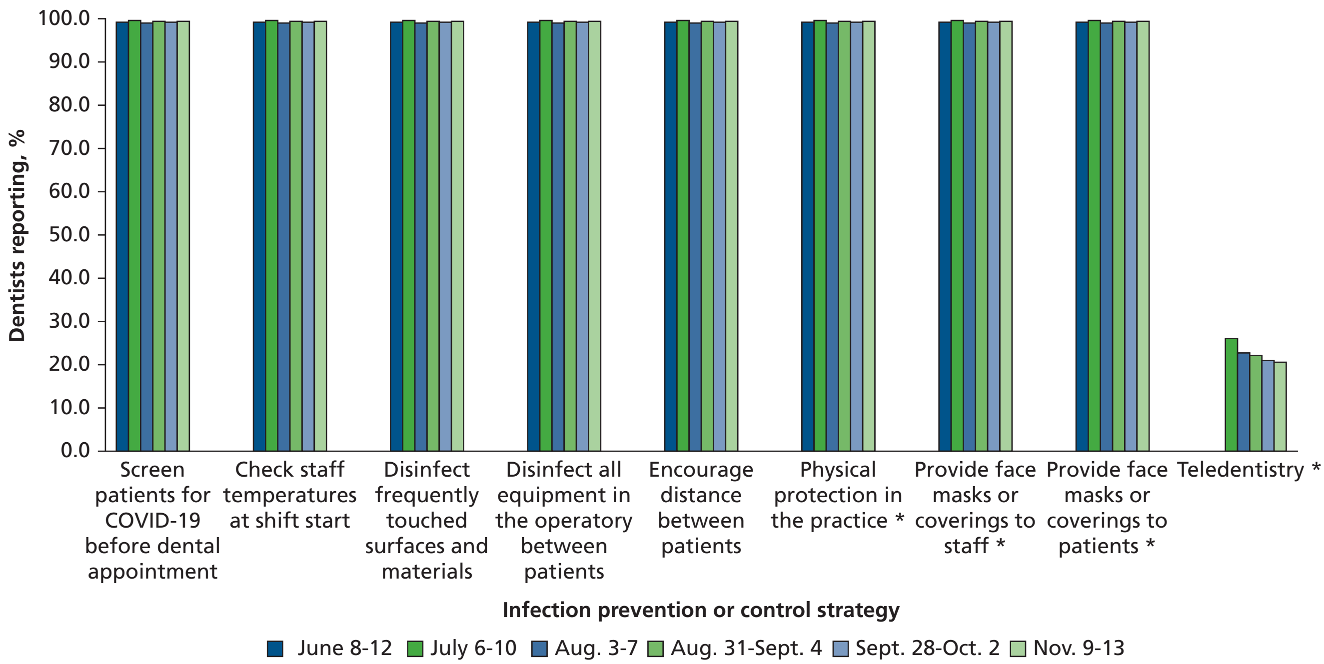

Figure 3. Infection prevention and control methods used in dental practices by month (8,966 observations, restricted to those practicing dentistry each month). * Significantly different over time, $P < .05$

or respirators between patients, and 407 (20.2%) changed them only if soiled or damaged. Over time, there was a decrease in PPE optimization, as significantly more dentists changed their masks with every patient ($P < .01$). Since June 2020, the rate never fell below 25.5%, and fewer dentists reported changing their masks only if soiled (by November, only 99 [8.2%] did so).

Enhanced infection prevention and control strategies in the dental practice were reported by at least 99.7% of all dentists each month (no significant change over time; $P = .2$). Throughout the study period, high and statistically unchanged numbers of dental practices reported screening patients and staff members for COVID-19, disinfecting between patients, and encouraging social distancing between patients ($P > .05$) (Figure 3). Although in the initial survey most dental practices already reported providing face masks to staff members and patients and had physical protections such as barriers, open windows, or air filters or scrubbers, an increasing proportion of practices instituted these strategies over time ($P < .01$). We added a question about teledentistry to the survey the second month, and the results showed that this was used at the highest rate in July (418 [26.1%]) and declined to 265 (20.5%) by November ($P < .01$).

The proportion of dentists who had been tested for COVID-19 increased over time, from 355 (16.6%) in the initial survey to 566 (43.9%) in the final survey. Testing for COVID-19 using saliva samples was relatively rare (47 [2.1%]) compared with testing with nasal or pharyngeal swabs (703 [32.0%]). A minority (317 [14.4%]) were tested for COVID-19 antibodies via blood samples. As of the first survey, 20 (0.9%) dentists reported having ever been told they had COVID-19 by a medical HCP. New cases identified in each subsequent month were tallied to calculate monthly incidence and cumulative prevalence rates (Figure 4). In total, our 6-month analysis showed a cumulative prevalence rate of 2.6%, representing 57 dentists ever with confirmed or probable COVID-19 infection. The weighted incidence rates varied month by month, ranging from 0.2% through 1.1% (Figure 4).

DISCUSSION

Owing to the aerosol-generating nature of many dental procedures, it was originally hypothesized that dentistry presented a high risk of transmitting SARS-CoV-2[10]; however, no confirmed cases of COVID-19 transmission related to patients' receiving oral health care have been reported to date. Furthermore, the results of our earlier cross-sectional study[5] and the results of this study show that prevalence and incidence rates among dentists continue to be very low in comparison with the population as a whole and with other HCPs.

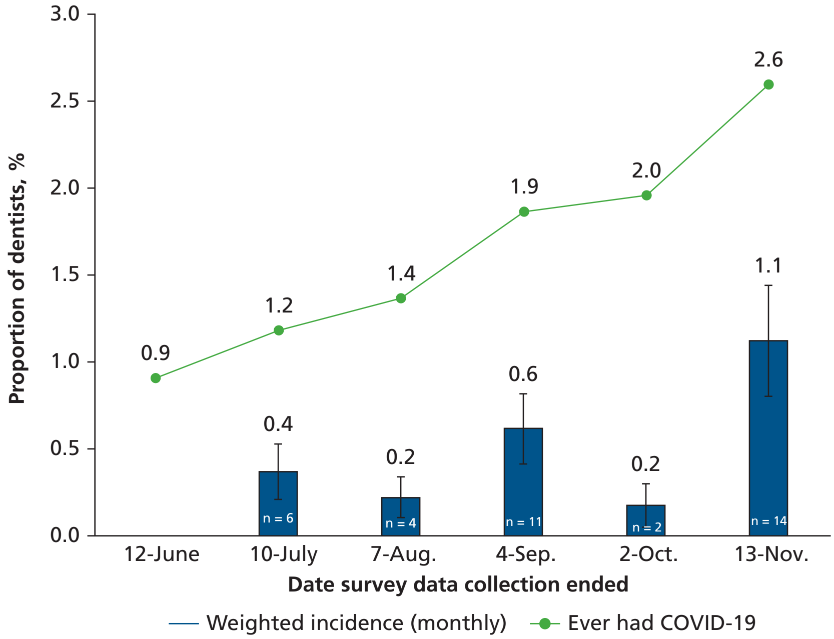

Figure 4. Monthly incidence and percentage ever had COVID-19 in survey of US dentists, June through November 2020 (n = 2,196).

At the conclusion of our study, robust data among front-line HCPs in the United States and the United Kingdom (2,035,395 HCPs) showed a higher rate of COVID-19 infection[11] compared with findings from our study. A prevalence of COVID-19 was found among 2,727 cases per 100,000 HCPs compared with 242 cases per 100,000 people in the general population. The high number of cases mostly were associated with direct contact with infected patients and lack of appropriate PPE, with the highest rates reported in large metropolitan areas such as New York, New York, and London, United Kingdom.[11] In addition, the same study showed that in the United States, 4.1% of medical HCPs were tested during the period of the study compared with 1.1% of the general population. In another report, results of a cross-sectional survey of front-line HCPs in the United States (n = 3,083) showed a reported prevalence rate of 29%,[12] which is much higher than the 2.6% rate among dentists reported in our study. In August 2020, 24% of employees of a large oncology hospital in New York, New York, were quarantined because of COVID-19.[13] Another cross-sectional study examined levels of antibodies among HCPs and indicated that 265 of the 500 HCPs tested showed presence of SARS-CoV-2 antibodies, possibly resulting from a previous infection with the virus.[14] Compared with these reports of nondental HCPs, our longitudinal data show lower rates for US dentists over the June through November 2020 time frame. Although the near universal adoption of enhanced PPE per the interim CDC guidance may have minimized the risk of getting an infection in the dental office, we also observed a higher rate of testing among dentists (up to 43.9%) than front-line HCPs. Despite this high testing rate, the cumulative prevalence among dentists in our survey was 2.6% by November 13, 2020.

Furthermore, dentists have shown continued low monthly incidence of disease despite several regional and national COVID-19 rate spikes during the study period. This may indicate that dentists are able to mitigate much of their own exposure in clinical environments through consistent use of enhanced PPE and interim guidance adherence. The results of our study show high rates of preappointment screening of patients and appropriate infection control measures throughout the study period.

The risk of getting SARS-CoV-2 infection decreases substantially with appropriate PPE use.[15] An important distinction between dentists and other HCPs is that many medical procedures that do not involve intubation for anesthesia can be performed while a patient is wearing a mask. However, dental procedures universally require patients to be seen unmasked. This highlights the importance of continued use of enhanced PPE, in particular N95 masks, and the need for continued availability and prioritization of such protections for dental HCPs. We observed a minor shift in the use of PPE during the 6-month period of our study, most likely owing to access to the equipment, clinical judgment, schedule planning, and other resources that dentists implemented since practice reopening. In mid-November 2020, 59.8% of dental practices in the United States reported having at least a 2-week supply of N95 or KN95 masks.[16] Expanded use of N95 masks may be limited by supply shortages and the number of hours each HCP may be exposed to potentially infected patients.

To our knowledge, this is the first large-scale longitudinal report of incidence rates of COVID-19 among dentists in the United States. The results of our report may show a decreased response rate over time but still present a sample that is nationally representative of US dentists. Our surveys also used the strictest definitions for infection prevention and control. These findings are self-reported and, therefore, subject to recall and social desirability biases. Unfortunately, the survey was limited to dentists' PPE use and whether they performed AGPs that month and thus did not entirely match CDC interim guidelines for PPE use; it did not ask about dentists' PPE use during AGPs compared with non-AGPs. Conceivably, dentists could answer the survey as sometimes wearing the correct PPE during a month they performed AGPs and be in compliance with CDC recommendations. Furthermore, not all dentists were tested for COVID-19 during the study; asymptomatic cases for which dentists did not seek testing or care were likely missed. We also could not survey participants who were hospitalized or died during our survey time frame. These people would not have been captured in this study. However, data on hospitalizations and deaths from March through May 2020 by health care occupation indicate both dental professionals and physicians had hospitalization rates below some occupations not expected to have patient contact, such as administrators.[17] Therefore, we expect our estimation of the monthly incidence and cumulative prevalence to be affected less by hospitalization or death than survey research in professions with higher rates of severe COVID-19 cases.

CONCLUSIONS

The level of adherence to enhanced infection control procedures in response to the COVID-19 pandemic continues to be high among US dentists. The low rates of cumulative prevalence (2.6%) and monthly incidence ranging from 0.2% through 1.1% reflect the high level of self-care among dentists. Oral health care is being delivered safely because dentists are showing adherence to a strict protocol for enhanced infection control, which should help protect their patients, their dental team members, and themselves. ■

SUPPLEMENTAL DATA

Supplemental data related to this article can be found at https://doi.org/10.1016/j.adaj.2021.03.021.

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1. Sommerstein R, Fux CA, Vuichard-Gysin, et al. Risk of SARS-CoV-2 transmission by aerosols, the rational use of masks, and protection of healthcare workers from COVID-19. *Antimicrob Resist Infect Control*. 2020;9(1):100.

2. Bianco F, Incollingo P, Grossi U, Gallo G. Preventing transmission among operating room staff during COVID-19 pandemic: the role of the Aerosol Box and other personal protective equipment. *Updates Surg*. 2020;72(3):907-910.

3. Centers for Disease Control and Prevention. Interim infection prevention and control guidance for dental settings during the COVID-19 response. December 4, 2020. Accessed 13 January 2021. https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html

4. World Health Organization. Clinical management of COVID-19. May 27, 2020. Accessed 13 January 2021. https://www.who.int/publications/i/item/clinical-management-of-covid-19

5. 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.

6. Froum SH, Froum SJ. Incidence of COVID-19 virus transmission in three dental offices: a six-month retrospective study. *Int J Periodontics Restorative Dent*. 2020;40(6):853-859.

7. Martinho FC, Griffin IL. A cross-sectional survey on the impact of Coronavirus disease 2019 on the clinical practice of endodontists across the United States. *J Endod*. 2021;47(1):28-38.

8. American Dental Association. ADA interim guidance for management of emergency and urgent dental care. Accessed 13 January 2021. https://web.archive.org/web/20200506114732/https://www.ada.org/~/media/CPS/Files/COVID/ADA_COVID_Int_Guidance_Treat_Pts.pdf

9. Centers for Disease Control and Prevention. Guidance for dental settings. December 4, 2020. Accessed 25 February 2021. https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html

10. Wei WE, Li Z, Chiew CJ, Yong SE, Toh MP, Lee VJ. Presymptomatic transmission of SARS-CoV-2: Singapore, January 23—March 16, 2020. Centers for Disease Control and Prevention. *Morb Mortal Wkly Rep*. 2020;69(14):411-412.

11. Nguyen LH, Drew DA, Graham MS; on behalf of the Coronavirus Pandemic Epidemiology Consortium, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. *Lancet Public Health*. 2020;5(9):e475-e483.

12. Firew T, Sano ED, Lee JW, et al. Protecting the front line: a cross-sectional survey analysis of the occupational factors contributing to healthcare workers' infection and psychological distress during the COVID-19 pandemic in the USA. *BMJ Open*. 2020;10:e 042752.

13. Press RH, Hasan S, Chhabra AM, Choi JI, Simone CB. Quantifying the impact of COVID-19 on cancer patients: a technical report of patient experience during the COVID-19 pandemic at a high-volume radiation oncology proton center in New York City. *Cureus*. 2020;12(4):e7873.

14. Venugopal U, Jilani N, Rabah S, et al. SARS-CoV-2 seroprevalence among health care workers in a New York City hospital: a cross-sectional analysis during COVID-19 pandemic. *Int J Infect Diseases*. 2021;102:63-69.

15. Seidelman JL, Lewis SS, Advani SD, et al. Universal masking is an effective strategy to flatten the severe acute respiratory coronavirus virus 2 (SARS-CoV-2) healthcare worker epidemiologic curve. *Infect Control Hospital Epidem*. 2020;41(12):1466-1467.

16. American Dental Association. COVID-19: economic impact on dental practices, week of December 14 results. Health Policy Institute. Accessed 13 January 2021. https://bit.ly/3r4MUDj

17. Kambhampati AK, O'Halloran AC, Whitaker M, et al. COVID-19-associated hospitalizations among health care personnel: COVID-NET, 13 states, March 1-May 31. *Morb Mortal Wkly Rep*. 2020;69(43):1576.

COVID-19 Prevalence and Related Practices among Dental Hygienists in the United States

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Abstract

Purpose: Throughout the COVID-19 pandemic, health care professionals have been challenged to provide appropriate preventive and therapeutic measures while using precautions to minimize disease transmission. The purpose of this study was to estimate the prevalence of COVID-19 among United States (US) dental hygienists, describe infection prevention and control procedures and any associated trends in mental health.

Methods: Registered dental hygienists (RDHs) licensed in the US were invited to participate in a 30-question web-based survey. COVID-19 infection items included probable and confirmed results, COVID-19 related symptoms experienced in the last month, and level of concern about COVID-19 transmission to patients and themselves. The validated Patient Health Questionnaire 4 screened respondents for depression or anxiety. Personal protective equipment (PPE) use when treating patients was assessed. The research protocol and survey were approved by the American Dental Association IRB and registered at clinicaltrials.gov (NCT04542915). Kruskal-Wallis and X^2 tests were used to test for associations between PPE use, PPE supply, mental health symptoms, and concern about COVID-19 transmission.

Results: As of October 8, 2020, a total of 4,776 dental hygienists from all 50 states and Puerto Rico participated in the study. Respondents reported elevated symptoms of anxiety and depression. Of the respondents, 3.1% (n=149) had ever tested positive or been diagnosed with COVID-19. The majority of respondents (99.1%; n=3,328) who practiced dental hygiene reported their primary dental practice had enhanced infection prevention or control efforts in response to the pandemic. PPE use was significantly associated with years of experience as a dental hygienist, level of concern about COVID-19, and level of PPE supplies available (p-values<0.01), but not type of dental practice (p-value 0.1).

Conclusion: As of October 2020, the estimated prevalence rate of dental hygienists in the US having had COVID-19 was low. There is a need for further support for dental hygienists' use of PPE and mental health.

Keywords: SARS-CoV-2, COVID-19, occupational health, infection control, personal protective equipment, dental hygienists

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Introduction

On February 11,2020, the *Coronaviridae* Study Group of the International Committee on Taxonomy of Viruses named the novel beta coronavirus as SARS-CoV-2.[1] This etiologic agent, or COVID-19 disease, has reached nearly every country worldwide in less than six months, resulting in significant morbidity and mortality. As of this article's publication date, there are over 63 million cases of COVID-19 globally, with over 1.4 million deaths, and over 17 million cases of COVID-19 in the United States (US) resulting in nearly 308,000 deaths.[2]

Infection and viral dissemination of SARS-Co-V-2 occurs through respiratory droplets from infected individuals while sneezing, coughing or talking without covering the mouth and nose.[3] The droplets may linger in the air and infect individuals who come into contact with them in an enclosed space.[4,5] Transmission is also possible through direct bodily contact with infected persons or contacting contaminated surfaces.[6]

Currently, there are limited therapeutic options for management of COVID-19. Supplemental oxygen and mechanical ventilation or extracorporeal membrane oxygenation for patients with refractory hypoxemia are used. Other therapies include convalescent plasma and immunoglobulin G, cortisone, and antiviral agents with limited success.[3,7] The development of several vaccines show promising results and are in active deployment. This accelerated development process for vaccines to prevent COVID-19 will necessitate further investigations concerning length of immunity, need for boosters, effects on high-risk populations, and equitable access.[8]

Throughout the pandemic essential workers have been challenged to provide appropriate preventive and treatment measures while using precautions to minimize disease transmission and risk. Due to close contact with patients, health care workers may be at increased risk of COVID-19 infection.[9] This risk may be heightened among oral health care workers, who may also be exposed to aerosolized infectious particles through aerosol-generating dental procedures such as scaling or polishing teeth with sonic or ultrasonic devices.[10] Alternately, dental professionals' customary use of personal protective equipment (PPE) and routine dental procedures, such as water irrigation and high-volume evacuation, may reduce infection risk.[11]

Dental professionals have been diagnosed with COVID-19,[12] but since community transmission is possible, and a retrospective study found no instances of dental-practice transmission of COVID-19 to staff or patients,[13] the level of occupational risk remains unresolved. A vital component of correctly balancing people's needs for oral health care, along with the occupational risk in providing such care, is an accurate assessment of the risk of COVID-19 transmission in dental practices. Unfortunately, data on COVID-19 among dental professionals in the US is limited. Most (84%) records available to the Centers of Disease Control and Prevention (CDC) are missing data on healthcare professions.[14]

A review of the literature related to COVID-19 infection control practices among dental professionals is limited, given the time frame of the initiation of this virus. Many of the studies have occurred in practice settings outside of the US. For example, one study examined the signs and symptoms, protective measures, awareness and perceptions levels of COVID-19 among dentists in Lombardy, Italy, during April 2020. A total of 9,247 survey invitations were emailed and 3,599 were completed for a response rate of 39.4%. Of the participants, almost 15% experienced one or more symptoms associated with COVID-19, most notably fever and fatigue. Thirty-one dentists tested positive for the virus and 16 individuals developed COVID-19 disease. Precautionary measures used most frequently included delaying patient appointments, so the waiting room was not crowded, increased ventilation of the waiting room, and operator handwashing before and after each procedure. Only two percent of participants were confident that they could avoid the infection.[15]

A report on a cross-sectional study of the knowledge and practice of dentists in Lebanon was conducted in April 2020. Using a sample size calculator, a sample size of 357 participants was sought among a total population of 5000 dentists; and 358 dentists completed the survey. Findings revealed the majority had good knowledge about COVID-19; however, deficits were noted related to coronavirus incubation periods, disease transmission, actions in dealing with positive cases, and precautionary measures. More than half of the respondents (60%) reported good practice while the remainder noted poor practices related to COVID-19. Over 80% of the respondents reported they were afraid to treat a patient suspected or confirmed as infected with COVID-19 and had concerns about becoming infected from a colleague. Nearly all respondents (96%) were afraid of the impact of this disease on their livelihood. The authors noted that these findings have implications for the development of strategies for improving practice and enhancing prevention programs.[16]

Dentists in Saudi Arabia were surveyed in May 2020 concerning questions about COVID-19, management in dental clinics, preventive measures in the reception area, and knowledge, practice and attitudes toward the pandemic. Of the 1,000 surveys sent, 287 responses were received for a response rate of 28.7%. Findings revealed good adherence to screening patients and adoption of preventive measures in the reception area. There was less agreement (46%) related to use of an isolation room for suspected COVID-19 patients. Similarly, most respondents reported that an airborne infection isolation room and extra-oral suction system did not exist in the dental clinic where they worked, and half reported their dental clinic did not offer proper management training sessions for their staff. Overall knowledge and attitude percentages were high. The authors noted that until a vaccine is developed, adhering to developed guidelines to prevent the transmission of the COVID-19 infection is imperative; yet one-third of the respondents had no work plan or were unaware of a work plan for patient screening and dental management in their practice setting. It was recommended dental clinics utilize additional educational sessions for their dentists and staff on the latest COVID-19 recommendations and closely monitor practitioners and staff to ensure adherence to guidelines.[17]

To date, only one national study of US dentists has been published. A web-based survey was conducted in June 2020 among dentists designed to determine the prevalence of COVID-19 and infection control practices of dentists in private practice or public health. Survey questions pertained to COVID-19 symptoms, SARS-CoV-2 infection, mental well-being, and infection control procedures used in practice. Most respondents (82.2%) had no COVID-19 related symptoms within the past month of survey administration; the most common symptom reported was headache. One-third experienced mild psychological distress. Prevalence and positive testing rates were low among the respondents with 16.6% being tested and 0.9% reporting confirmed or probable COVID-19 cases. Enhanced infection control practices were implemented among nearly all respondents (99.7%) and the majority of practices (72.8%) used PPE according to CDC interim guidance. The authors concluded that the use of the CDC interim guidance in dental practice settings will contribute to reduced risk of developing infection and noted that surveillance of US dentists will remain ongoing.[18]

While organizations have continued to issue training, guidelines, and toolkits related to practicing oral health care during the COVID-19 pandemic,[19,20] the actual infection prevention and control practices of dental hygienists have been not been reported on since May 2020.[21,22] One international study involved the impact of the pandemic on the dental hygiene profession from a global perspective. This study evaluated dental hygienists from 30 countries belonging to International Federation of Dental Hygienists and included 9,866 respondents (response rate not provided). Respondents indicated that guidance and PPE measures were being employed. Protective measures included screening patients for symptoms upon arrival (81%) and by phone when scheduling appointments (71%) and disinfecting all operatory surfaces after treatment (85%). Gloves, faces shields and surgical masks were being used by the majority of respondents. Nearly half reported wearing an N95 respirator, goggles, full gown and/or hair covering. However, concerns were expressed about PPE shortages (83%) and regarding patients delaying dental care (74%). Less than 2% had been diagnosed with COVID-19 and of those, fewer than 1% had symptoms.[21]

A cross-sectional survey of dental hygienists in Italy was performed during May 2020. This study used the same questionnaire that had been sent to dentists in Lombardy, Italy. Of 6,974 surveys sent, 2798 were entirely or partially completed, for a response rate of 40.12%. Findings revealed participants experienced symptoms of fatigue, headache and sore throat. Only 0.25% reported a positive diagnosis of COVID-19. Most frequent precautionary measures included telephone triage, spacing appointments, frequent ventilation and disinfection of the waiting room, and handwashing before and after procedures performed. Protective glasses or visor, disposable gloves and surgical mask were the PPE most frequently used. The authors concluded that respondents appeared to be prepared to manage the COVID-19 infection in the dental practice environment and seemed confident being able to avoid the infection while performing work-related activities.[22]

Presently, no studies have reported specifically regarding dental hygienists' COVID-19 practice experiences in the US. Therefore, a longitudinal survey was constructed to estimate the burden of COVID-19 among dental hygienists in the US, evaluate trends in mental health and professional practices, and identify COVID-19 risk factors for dental hygienists. The results from the first month's survey are reported here to describe COVID-19 prevalence, health, and COVID-19 related behaviors and practices among dental hygienists in the US.

Methods

A web-based survey was administered using Qualtrics (Qualtrics, Provo, UT) from September 29-October 8, 2020. All 133,000 registered dental hygienists who were in the American Dental Hygienists' Association's (ADHA) database received an invitation to participate on September 29, 2020; and a reminder invitation was emailed October 6, 2020. Individuals were eligible to participate in the survey if they were licensed as a dental hygienist in the US, were at least 18 years old, and were employed as a dental hygienist on March 1, 2020.

Potential participants read and signed an electronic informed consent before responding to the survey. The 30-question survey was constructed for this research and similar to the survey of US dentists.[18] Based on the first two months of identical questions among a panel of dentists, test-retest reliability was on average 85.4%. Demographic survey questions included birth year, race, ethnicity, gender, primary practice location, and years of experience as a dental hygienist. COVID-19 infection was ascertained by self-reported date, type, and positive result of a COVID-19 test (confirmed case) or, if not tested, the date a healthcare provider told the respondent they had COVID-19 (probable case). COVID-19 prevalence was estimated based on this information. Consistent with CDC surveillance, the positive test rate was defined by the numbers of confirmed cases over the total number of tested cases.[23] Respondents were also asked to identify symptoms experienced in the last month (defined as since August 29, 2020), health conditions associated with COVID-19 severity,[24] and dental and non-dental activities in the last month.

Since stressful events such as a pandemic may affect mental well-being, respondents were asked their level of concern about COVID-19 transmission to patients and to themselves on a 5 point scale (1 meaning "very concerned" and 5 meaning "not concerned at all), and the validated Patient Health Questionnaire 4 (PHQ-4) screened respondents for depression (using the PHQ-2 scale) or anxiety (using GAD-2).[25,26] Respondents who reported providing dental care in the last month were asked about infection prevention or control procedures in their primary dental practice. Respondents indicated which PPE they used when treating patients in the past month, and whether they used it sometimes, or always. The CDC interim guidance document was used to categorize PPE use,[19] such that respondents were categorized as following PPE guidance for aerosol-generating procedures, if in addition to basic clinical PPE of gloves and protective clothing, they wore an N95 or similarly protective respirator (also called N95 mask) with eye protection. Dental hygienists who performed no aerosol-generating procedures in the past month were categorized as following PPE guidance if they wore gloves, protective clothing, a surgical mask (or a mask or respirator that offers an even higher level of protection) and eye protection. Finally, respondents who reported wearing respirators or masks were asked how often they were changed. The research protocol and survey were approved by the American Dental Association Institutional Review Board and registered at clinicaltrials.gov (NCT04542915).

Proportions, frequencies, and means were calculated in Stata 13.0 (StataCorp LP, Texas). For categorical variables, differences were tested using X^2 tests, and with Kruskal-Wallis tests for non-normal continuous variables, with statistical significance set at 0.05. Due to complex survey design skip patterns, and because respondents were able to skip any question or stop answering the survey at any time, not all respondents answered all questions; the percent missing ranged from <1 to 9% per question. Since respondents' behaviors, health, and concern may be related to the level of COVID-19 risk in their area, the average incidence rate of COVID-19 in their state or territory, for the days included in the survey (August 29-October 8, 2020), was calculated using data made publicly available by Johns Hopkins University.[27]

Results

Of the dental hygienists identified in the ADHA database, 4,804 volunteered to participate in this research study. Of these individuals, a total of 4,776 dental hygienists originating from all 50 states and Puerto Rico participated in the web-based survey from September 29-October 8, 2020 for a completion rate of 99.4%. Respondents were aged 18 to 77 years (mean: 44.1, standard deviation: 12.0). The majority were non-Hispanic White (72.5%, n=4,066), female (98.1%,n=4,034), and primarily worked in a private solo dental practice (52.5%, n=2,161). Of the total sample, 31.9% (n=1,523) had at least one medical condition associated with a higher risk of developing severe illness from SARS-CoV-2.[24] Respondents had varying levels of experience, but the majority (64.4%, n=2,655) had been a practicing, licensed dental hygienist for 11 years or more. Demographic information is summarized in Table I. Dental hygienists were asked regarding their experiences of symptoms associated with COVID-19, even if they thought the symptoms were not due to COVID-19. Respondents could report multiple symptoms. The most common physical symptoms experienced in the past month were headaches (32.2%, n=1,547), congestion (24.8%, n=1,189), or fatigue (17.3%, n=829) (Table II). Respondents also answered the Patient Health Questionnaire-4, which evaluates symptoms of anxiety and depression. In the two weeks before taking the survey, 25.7% (n=1,077) of the respondents experienced elevated symptoms of anxiety (GAD-2 mean:1.73, standard deviation: 1.84) and 16.05% (n=673) experienced elevated symptoms of depression (PHQ-2 mean:1.21, standard deviation:1.59). Symptoms of anxiety and depression were significantly associated with age, with the highest levels of symptoms among those aged 18-29 years and the lowest levels among those aged 64 years or older (Kruskal-Wallis *p*-values <0.01).

Dental hygienists were surveyed regarding activities outside of their home in the past month (Table II). Of those responding, 18.8% (n=896) reported no contact with those outside of their household. Less than a third (32.4%; n=1,548) reported interacting with a group of ten or more people, while 12.8% (n=610) had attended a large public event in the past month. Only 9.1% (n=436) of dental hygienists reported they had in-person contact with someone with suspected or confirmed COVID-19 in the past month.

In the month preceding the survey, 70.3% (n=3,357) responding dental hygienists had provided dental care to patients as summarized in Table III. For the majority of respondents (90.7%; n=3,037), this care included dental procedures likely to generate aerosols. Among those who practiced dentistry that month, 99.1% (n=3,328) reported at least one enhanced infection prevention or control effort in their primary dental practice. The most common methods were disinfection between patients (97.9%, n=3,287), staff masking (97.8%, n=3,284), and screening patients prior to dental treatment (96.7%, n=3,247) (Table III). Most respondents (96.8%, n=3,249) reported that their primary

Table I. Sample demographics (n=4776)

Characteristic	%	n
Age group (years)		
18-29	12.5	500
30-39	28.2	1133
40-49	23.9	961
50-64	31.2	1254
65-77	4.2	169
Race/ethnicity		
Non-Hispanic White	72.5	4066
Hispanic/Latino	5.9	331
Non-Hispanic Asian	2.8	154
Non-Hispanic Black	1.8	100
American Indian/Alaska Native	0.6	34
Native Hawaiian/Pacific Islander	0.2	9
Other	16.3	916
Gender		
Male	1.0	42
Female	98.1	4034
Other or prefer not to say	1.0	40
Dental practice type		
Private solo practice	52.5	2161
Other dental practice	38.4	1581
Public health clinic/Community health center/Federally Qualified Health Center/ Tribal health center	4.5	185
Academic/university/college	2.8	115
School-based setting	1.0	40
Military	0.5	19
Other	0.3	14

Characteristic	%	n
Experience as a dental hygienist (years)		
0-10	35.6	1468
11-20	27.6	1136
21 or more	36.8	1519
US Census Bureau division		
New England	9.0	341
Middle Atlantic	11.5	439
East North Central	16.2	616
West North Central	7.3	276
South Atlantic	17.2	654
East South Central	5.0	190
West South Central	7.2	274
Mountain	10.4	397
Pacific	16.3	621
Territories	0.03	1
Conditions (multiple conditions per person allowed)		
Asthma	9.5	455
Chronic lung disease	0.5	23
Diabetes	2.2	106
Heart condition	3.0	96
Immunocompromised	2.9	140
Kidney disease	0.4	17
Liver disease	0.3	12
Obesity	8.4	402
Rheumatologic or autoimmune condition	5.3	255
Smoking	1.8	85
Other	9.0	432

dental practice had at least five different infection control practices in place. A minority of respondents also reported their primary dental practice asked staff (2.3%, n=78), patients (28.8%, n=968), or both (12.0%, n=401) to sign a waiver related to COVID-19 (Table III).

At the time of the survey, CDC interim guidelines for PPE included wearing eye protection in addition to a mask during all patient care encounters, and using an N95 respirator or equivalent during dental procedures likely to generate aerosols.[19] Among the respondents who provided oral health care that month, 28.2% (n=945) reported not following the CDC interim guidelines for PPE for patient care (Table III). Dental practice type was not statistically significantly associated with whether hygienists used PPE according to CDC guidelines (X^2 *p*-value=0.1) (Table IV). However, years of experience as a dental hygienist was significantly associated with always following CDC PPE guidelines. Over half, (54.6%, n=659) of those with 10 or less years of experience always used PPE according to guidelines, compared with 55.4% (n=511) of those with 11-20 years, and 60.7% (n=692) of those with 21 or more years of experience (X^2 *p*-value<0.01) (Table IV). Respondents expressing the highest levels of concern regarding COVID-19 transmission to themselves or patients were more likely to always use PPE according to CDC guidelines (Kruskal-Wallis tests *p*-values <0.01). The incidence of COVID-19 in their state during the study period was not statistically significantly associated with whether dental hygienists always wore PPE according to CDC guidelines (Kruskal-Wallis test *p*-value=0.4).

Table II. Recently reported symptoms and activities (n=4776)

	%	n
Physical symptoms in the last month		
Chills	3.1	147
Congestion or runny nose	24.8	1189
Diarrhea	11.2	536
Dry cough	8.9	427
Fever	1.8	84
Headache	32.2	1547
Muscle pain or body aches	16.7	800
Nausea or vomiting	5.1	244
New loss of taste or smell	1.6	79
Repeated shaking with chills	0.5	25
Sore throat	13.5	647
Shortness of breath or difficulty breathing	5.1	245
Fatigue/malaise	17.3	829
Other	2.9	141
Mental health in last two weeks		
Likely anxiety (GAD-2 ≥3)	25.7	1077
Likely depression (PHQ-2 ≥3)	16.0	673
Activities in the past month		
Provided emergency dental care	11.8	564
Provided elective dental care	69.8	3334
Attended a health care visit for myself or a companion	47.3	2259
Met in person with anyone outside your household	76.4	3650
Met with a group of 10 or more people in a social setting	32.4	1548
Attended any public event with 50 or more people	12.8	610
Traveled by taxi, ride share, or public transportation	8.1	388
Met in-person with anyone with suspected or confirmed COVID-19:	9.1	436
Member of household	1.3	63
Coworker	3.5	168
Dental patient	2.8	135
Someone else	2.9	139

Dental hygienist use of N95 respirators was statistically significantly associated with the number of days' supply of N95 respirators, or their equivalent, in their primary place of employment. Only 1.3% of respondents always used N95s during patient care if their practice had 0 days' supply. However, this percentage increased with increasing supply, such that 14.2% always used N95s if they had 8-14 days' supply, and 61.9% always used N95s if their practice had more than 14 days' supply (X^2 p-value<0.01). Since CDC interim guidance includes the use of a N95, or equivalents, during aerosol-generating dental procedures, it naturally followed that practice level of supplies of N95 or equivalent respirators was also significantly associated with respondent's use of PPE according to CDC guidelines (Table IV). Respondents most commonly reported changing their mask or respirator between each patient (42.3%, n=1157); the remainder changed it less often. Respondents who had more than 14 days of surgical masks or N95 or equivalent respirators were most likely to change their mask or respirator between every patient (X^2 p-values <0.01).

Dental hygienists were asked if they had ever been tested or diagnosed with COVID-19. Approximately one-third (35.4%, n=1,691) had been tested for SARS-CoV-2 at least once. The most common testing method utilized nasal or throat swabs (33.1%, n=1,583), with a 7.8% positive test rate (n=123). Only 5.4% (n=260) were tested using blood samples, with an 8.5% positive test rate (n=22). The least common testing method used were saliva samples, reported by 1.4% of respondents (n=65), with a 4.6% (n=3) positive test rate. Twenty-three (0.5%) dental hygienists surveyed were not able to be tested but were diagnosed with COVID-19 by a physician. In total, 3.1% (n=149) of the respondents had ever had COVID-19 by October 8th, 2020 (Table V). About one third of the dental hygienists with COVID-19 (37.8%, n=55) reported that contact tracing for the likely source of their COVID-19 infection was performed. For 25.5% (n=14) of those traced, contact tracing identified the respondent's primary place of work as the likely source of transmission.

Not all respondents remembered the date for which they sought testing or medical care for COVID-19, however, 10.3% (n=492) reported being tested or diagnosed since September 1, 2020. In total, 0.8% (n=39) of the respondents were diagnosed with COVID-19 or tested positive between September 1, 2020 and October 8, 2020, while 9.5% (n=453) tested negative for COVID-19. Among those tested or diagnosed in the past month, a significantly higher proportion of those

Table III. Reported infection prevention and control efforts in dental practices (n=3357)*

	Reporting (%)	n
Infection prevention and control efforts in the past month		
Screen or interview patients for known or suspected COVID-19 infection before dental appointment or treatment	94.0	3157
Check patient temperatures with a thermometer before dental treatment	96.7	3247
Check dental hygienist's temperature with a thermometer at the beginning of their shift	86.5	2904
Disinfect frequently touched surfaces and materials such as pens or light switches	91.4	3069
Disinfect all equipment in the operatory between patients	97.9	3287
Encourage distance between patients, such as scheduling appointments farther apart, asking patients to wait elsewhere, or asking patients not to bring companions	85.7	2876
Physical protection in the practice, such as erecting barriers, opening windows, or using air filters or scrubbers	75.0	2516
Provide face masks or coverings to staff	97.8	3284
Provide face masks or coverings to patients	71.6	2404
Teledentistry	14.8	497
Other	7.5	250
COVID-19 related waiver		
Dental practice asks staff or patients to sign a waiver	43.1	1447
No waiver	55.3	1857
Unknown	1.6	53
Personal Protective Equipment while treating patients in the past month		
Did not report using PPE according to current CDC interim guidelines	28.2	945
Sometimes used PPE according to current CDC interim guidelines	16.1	541
Always used PPE according to current CDC interim guidelines	55.7	1871

* Limited to respondents who performed dental procedures in the past month

with symptoms (11.6%, n=36) had COVID-19 than without (1.7%, n=3) (p-value<0.01). There was no statistical difference in COVID-19 positive tests in the past month among those who practiced (1.9%, n=48) or did not practice dental hygiene (1.1%, n=14) in the past month (X^2 p-value= 0.09). There was also no statistical difference in COVID-19 incidence rate in their state or territory between those who tested positive or negative since September 1, 2020 (Kruskal-Wallis p-value = 0.9).

Discussion

This study is one of the only descriptions of COVID-19 prevalence, infection control practices or PPE use among dental hygienists in the US during the COVID-19 pandemic. Dental hygienists' rates of enhanced infection control procedures in dental practices are similar to the rates reported by US dentists[18] and higher than those found in international surveys of dental hygienists.[21,22]

Similar to other surveys of dental hygienists practicing during the pandemic,[21,22] not all dental hygienists participating in the present study reported wearing N95 or equivalent respirators. As was found in a study among Italian dental hygienists,[22] years of experience, but not community level of COVID-19 infections, are associated with PPE use. As intuitively makes sense, in the current study, dental hygienists' use of N95 or equivalent respirators was associated with respirator availability at their workplace. Increasing dental practices' supplies of N95, or equivalent respirators, may enhance PPE use. Alternatively, if dental practices followed national guidance and avoided aerosol generating procedures whenever possible, the limited supply and use of N95 or equivalent respirators by dental professionals would not be as problematic.[19,20]

The issue of national guidance to protect dental health care personnel and patients from infection is an important consideration. This study revealed that slightly more than half of the respondents (55.7%) always used PPE according to current CDC interim guidance. Consistent adherence to PPE guidance was highest among those who were most concerned about COVID-19, had more years of experience as a dental hygienist, or had higher supplies of N95 or their equivalent. A global study of dental hygienists indicated that almost half of respondents were wearing an N95 respirator, goggles, full gown and/or hair covering, but the majority (92%) indicated that they would have to wear more PPE in the future. They were also

Table IV. Factors associated with adherence to CDC Interim Guidelines for PPE (n=3357)*

Characteristic	Always used PPE according to CDC interim guidelines (%)	n	X^2 *p*-value
Dental practice type			0.1
Private solo practice	54.5	952	
Other dental practice	56.2	731	
Public health clinic/Community health center/Federally Qualified Health Center/Tribal health center	62.0	85	
Academic/university/college	70.4	50	
School-based setting	50.0	9	
Military	53.9	7	
Other	55.6	5	
Experience as a dental hygienist (years)			<0.01
0-10	54.6	659	
11-20	55.4	511	
21 or more	60.7	692	
N95 or equivalent masks or respirators supply			<0.01
Not sure	52.5	253	
0 days	13.6	29	
1-7 days	46.4	185	
8-14 days	58.3	266	
More than 14 days	63.8	1112	

* Limited to respondents who had performed dental procedures in the past month

Table V. Probable and confirmed COVID-19 infection (n=4776)*

Tested for COVID-19	Tested (%)	n	Positive test (%)	n
Nasal or throat swab (tests for current SARS-CoV-2 virus)	33.1	1583	7.8	123
Blood sample (tests for past SARS-CoV-2)	5.4	260	8.5	22
Saliva sample (tests for current SARS-CoV-2 antigen)	1.4	65	4.6	3
Not tested, but diagnosed by healthcare provider	NA**	NA	0.5	23
Total ever tested positive or had positive diagnosis	3.1	149	NA	NA

*Multiple types of testing may have been performed

** not applicable

concerned (>80%) that there would not be an adequate supply of PPE to treat patients.[21] A study of Italian dental hygienists revealed a higher level of adherence to national and international guidelines for use of PPE , but less so with other precautionary measures.[22] Further study is needed to identify other factors that may be associated with strict adherence to guidelines including awareness of current guidelines, philosophy of dental practice, availability of other PPE, and financial issues.

The Joint American College of Academic International Medicine-World Academic Council of Emergency Medicine Working Group on COVID-19 caution that significant rates of anxiety, depression, and other mental health disorders among the general health population, as well as health care providers, are to be expected, including suicidal ideation and suicide. The proportion of dental hygienists experiencing anxiety in the present study (25.7%) is similar to anxiety levels found among the general US population (25.5%), during the COVID-19 pandemic; however respondents had lower levels of depression (16,0%) as compared to the general population (24.3%).[28] In comparison, dentists in the US reported lower rates of anxiety (14.8%) and depression (8.9%) than the dental hygienists;[18] however, nurses in Michigan reported significantly higher rates of anxiety (54.95%) and depression (59.5%)[29] than either dentists or dental hygienists. A study of dentists and dental hygienists in Israel revealed a low rate of elevated psychological distress, found (11.5%) experiencing distress, most notably associated with those who had background illness, fear of contracting COVID-19 from a patient, and higher subjective overload.[30] These differences in mental health symptoms by profession may reflect longer periods of contact with potentially infectious patients, may be related to levels of perceived control in the workplace, age differences, or other factors, and warrant further investigation. These findings underscore the importance of mental health resources needed to help individuals cope with the emotional stress of the pandemic.[31]

As of October 8, 2020, an estimated 3.1% of dental hygienists in the US have had COVID-19. In the general US population on the same date, an estimated 2.3% or 7.6 million people have had COVID19.[2] Both of these cumulative prevalence rates are lower than has been found in non-dental, health care workers in the US.[32] The two international studies focusing on dental hygienists also reported prevalence rates of less than 2%.[21.22] The low rate reported in the present study may reflect the safety measures taken by dental hygienists to protect their patients and dental team members.

There are limitations to these findings. This study is based on self-reported data, which may be subject to recall or social desirability bias. COVID-19 testing is limited and is primarily available to those with symptoms or contact with someone who has already tested positive for COVID-19, so, as with surveillance in the general US population,[23] less severe, or asymptomatic cases of COVID-19, may be missed. Severe cases of COVID-19 resulting in hospitalization or death would also be underestimated by this study. There was insufficient statistical power to test for differences in recent COVID-19 infection by dental-practice-related factors, such as PPE use or infection control practices.

Future research, using data from this ongoing longitudinal study, may be able to evaluate these factors and will continue to examine prevalence of COVID-19 among dental hygienists in the US, risk factors for COVID-19, use of PPE in dental practice settings, employment factors, and mental health status. Further study is needed to identify other factors that may be associated with COVID-19 infection including awareness of, and strict adherence to guidance, philosophy of dental practice, availability of other PPE, and financial issues.

Conclusion

As of October 2020, the prevalence of ever having had COVID-19 was estimated to be 3.1% among dental hygienists in the US. Enhanced infection control efforts were reported in 99.1% of dental practices. Not all dental hygienists reported using PPE during dental procedures according to CDC interim guidelines; this finding may improve with increased access to PPE. Ongoing data collection among this sample,will enable estimation of the incidence rate of COVID-19 among US dental hygienists and identifying dental practice-related risk factors for SARS-CoV-2 infection.

Disclosure

The authors have no conflicts of interest to report.

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References

1. Gorbalenya AE, Krupovic M, Mushegian A, et al. The new scope of virus taxonomy: partitioning the virosphere into 15 hierarchical ranks. Nat Microbiol. 2020 May; 5(5):668-74.
2. John Hopkins University & Medicine. Coronavirus Resource Center. COVID-19 dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University [Internet]. Baltimore (MD): JHU.edu; 2020 [cited 2020 November 30]. Available from: https://coronavirus.jhu.edu/map.html
3. Macchi J, Herskovitz J, Senan AM, et al. The natural history, pathobiology, and clinical manifestations of

SARS-CoV-2 infections. J Neuroimmune Pharmacol. 2020 Jul; 21:1-28.

4. Gandhi M, Yokoe DS, Havlir DV. Asympotomatic transmission, the Achilles' heel of current strategies to control COVID-19. N Engl J Med. 2020 May; 382 (21):2158-60.

5. Meselson M. Droplets and aerosols in the transmission of SARS-CoV-2. N Engl J Med. 2020 May; 382 (21):2063.

6. Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. N Engl J Med. 2020 Mar; 382:1199-1207.

7. Guo Y-R, Cao Q-D, Hong Z-S, et al. The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak – an update on the status. Mil Med Res. 2020 Mar 13; 7(1):11.

8. Jeyanathan M, Afkhami S, Smaill F, et al. Immunological considerations for COVID-19 vaccine strategies. Nat Rev Immunol. 2020 Oct; 20(10):615-32.

9. Nguyen LH, Drew DA, Graham MS, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. Lancet Public Health. 2020 Sep;5(9):e475-e83.

10. Ge Z-Y, Yang L-M, Xia J-J, et al. Possible aerosol transmission of COVID-19 and special precautions in dentistry. J Zhejiang Univ Sci B. 2020 May;21(5):361-8.

11. Epstein JB, Chow K, Mathias R. Dental procedure aerosols and COVID-19. Lancet Infect Dis.2020 Aug 10;S1473-3099

12. Meng L, Hua F, Bian Z. Coronavirus disease 2019 (COVID-19): emerging and future challenges for dental and oral medicine. J Dent Res. 2020 May;99(5):481-7.

13. Froum SH, Froum SJ. Incidence of COVID-19 virus transmission in three dental offices: a 6-Month retrospective study. Int J Periodontics Restorative Dent. 2020 Oct; 40(6):853-9.

14. Burrer SL, de Perio MA, Hughes MM, et al. Characteristics of health care personnel with COVID-19 United States, February 12–April 9, 2020. MMWR Morb Mortal Wkly Rep 2020 Apr 17;69(15):477-81.

15. Cagetti MG, Cairoli JL, Senna A, et al. COVID-19 outbreak in North Italy: an overview on dentistry. A questionnaire survey. Int J Environ Res Public Health. 2020 Jun; 17(11):3835.

16. Nasser Z, Fares Y, Daoud R, et al. Assessment of knowledge and practice aof dentists towards Coronavirus disease (COVID-19): a cross-sectional survey from Lebanon. BMC Oral Health. 2020 Oct; 20:281.

17. Al-Khalifa KS, SlSheikh R, Al-Swuailem AS, et al. Pandemic preparedness of dentists against coronavirus diseas: a Saudi Arabian experience. Plos One. 2020 Aug; 15(8): e0237630.

18. Estrich CG, Mikkelsen M, Morrissey R, et al. Estimating COVID-19 prevalence and infection control practices among US dentists.J Am Dent Assoc. 2020 Nov; 151(11):815-24.

19. CDC. Interim infection prevention and control guidance for dental settings during the COVID-19 response [Internet] Atlanta,(GA): U.S. Department of Health and Human Services; 2020 [modified 2020 Jun 29; cited 2020 Nov 30]. Available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html

20. ADHA. ADHA COVID-19 center 2020 [Internet] Chicago (IL): American Dental Hygienists' Association; 2020 [modified 2020 Nov 23; cited 2020 Nov 30] Available from: https://www.adha.org/covid19

21. IFDH. IFDH 2020 COVID survey [Internet} Rockville (MD): International Federation of Dental Hygienists; 2020 [modified Jul 24; cited 2020 Nov 30] Available from: http://www.ifdh.org/ifdh-2020-covid-survey.html

22. Bontà G, Campus G, Cagetti MG. COVID-19 pandemic and dental hygienists in Italy: a questionnaire survey. BMC Health Serv Res. 2020 Oct 31;20(1):994.

23. CDC. Coronavirus disease 2019 (COVID-19): cases, data, & surveillance: purpose and methods [Internet] Atlanta,(GA): U.S. Department of Health and Human Services; 2020 [modified 2020 Jul 5; cited 2020 Dec 1] Available from: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/purpose-methods.html

24. CDC. Coronavirus disease 2019 (COVID-19): who is at increased risk for severe illness? [Internet] Atlanta,(GA): U.S. Department of Health and Human Services; 2020 [modified Jun 25; cited 2020 Dec 1] Available from: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-at-higher-risk.html

25. Löwe B, Wahl I, Rose M, Spitzer C, et al. A 4-item measure of depression and anxiety: validation and standardization of the Patient Health Questionnaire-4 (PHQ-4) in the general population. J Affect Disord. 2010 Apr; 122(1-2):86-95.

26. Pfizer. Patient Health Questionnaire Screeners [Internet]. New York (NY): Pfizer Inc; 2020 [modified 2020 May 5; cited 2020 Dec 1] Available from: https://www.phqscreeners.com/select-screener

27. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020 May 20;(5):533-4.

28. Czeisler MÉ, Lane RI, Petrosky E, et al. Mental health, substance use, and suicidal ideation during the COVID-19 pandemic—United States, June 24–30, 2020. MMWR Morb Mortal Wkly Rep. 2020 Aug; 69(32):1049-57.

29. Arnetz JE, Goetz CM, Sudan S, et al. Personal protective equipment and mental health symptoms among nurses during the COVID-19 pandemic. J Occup Environ Med. 2020 Nov; 62(11):892-7.

30. Shacham M, Hamama-Raz Y, Kolerman R, et al. COVID-19 factors and psychological factors associated with elevated psychological distress among dentists and dental hygienists in Israel. Int J Environ Res Public Health. 2020 Apr;17(8):2900.

31. Stawicki SP, Jeanmonod R, Miller AC, at al. The 2019-2020 novel coronavirus (severe acute respiratory syndrome coronavirus 2) pandemic: a joint American college of academic international medicine-world academic council of emergency medicine multidisciplinary COVID-19 working group consensus paper. J Glob Infect Dis. 2020 Apr-Jun; 12(2):47-93.

32. Kambhampati AK. O'Halloran Ac, Whitaker M, et al. COVID-19-associated hospitalizations among health care personnel--COVID-NET, 13 States, March1-May31, 2020. MMWR Morb Mortal Wkly Rep. 2020 Oct; 69(43):1576-83.

Cover Story

Estimating COVID-19 prevalence and infection control practices among US dentists

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Supplemental material is available online.

ABSTRACT

Background. Understanding the risks associated with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission during oral health care delivery and assessing mitigation strategies for dental offices are critical to improving patient safety and access to oral health care.

Methods. The authors invited licensed US dentists practicing primarily in private practice or public health to participate in a web-based survey in June 2020. Dentists from every US state (n = 2,195) answered questions about COVID-19—associated symptoms, SARS-CoV-2 infection, mental and physical health conditions, and infection control procedures used in their primary dental practices.

Results. Most of the dentists (82.2%) were asymptomatic for 1 month before administration of the survey; 16.6% reported being tested for SARS-CoV-2; and 3.7%, 2.7%, and 0% tested positive via respiratory, blood, and salivary samples, respectively. Among those not tested, 0.3% received a probable COVID-19 diagnosis from a physician. In all, 20 of the 2,195 respondents had been infected with SARS-CoV-2; weighted according to age and location to approximate all US dentists, 0.9% (95% confidence interval, 0.5 to 1.5) had confirmed or probable COVID-19. Dentists reported symptoms of depression (8.6%) and anxiety (19.5%). Enhanced infection control procedures were implemented in 99.7% of dentists' primary practices, most commonly disinfection, COVID-19 screening, social distancing, and wearing face masks. Most practicing dentists (72.8%) used personal protective equipment according to interim guidance from the Centers for Disease Control and Prevention.

Conclusions. COVID-19 prevalence and testing positivity rates were low among practicing US dentists. This indicates that the current infection control recommendations may be sufficient to prevent infection in dental settings.

Practical Implications. Dentists have enhanced their infection control practices in response to COVID-19 and may benefit from greater availability of personal protective equipment. ClinicalTrials.gov: NCT04423770.

Key Words. SARS-CoV-2; COVID-19; dentistry.

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The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the causative agent for an infectious disease known as COVID-19, which is transmitted primarily through person-to-person contact.[1] The COVID-19 pandemic, with its considerable morbidity and mortality, causes social and economic disruptions and health care delivery problems. The pandemic is of particular concern owing to the airborne transmission dynamics in asymptomatic and presymptomatic people.[2-4] Virus-containing droplets (5-12 micrometers) and aerosols ($\leq$ 5 μm) from infected people are transmitted into the environment through breathing, speaking, coughing, and sneezing.[5] Susceptible people can then become infected if virus-containing respiratory droplets or aerosols settle on mucosal membranes or are inhaled.[5] Respiratory viruses like SARS-CoV-2 can also be spread if a susceptible person touches viral particles on contaminated surfaces and transfers them to their mucus membranes.[5]

As information about SARS-CoV-2 transmission emerged during the early stages of the pandemic, concern regarding the transmission of virus-containing airborne particles in the dental office was also brought to the forefront. It has been suggested that additional potential for SARS-CoV-2 transmission exists in dental settings during the delivery of aerosol-generating dental procedures (AGDPs). These AGDPs might be potential vectors for patient-to-practitioner and patient-to-patient transmission, as the aerosols and droplets produced during such procedures can contain infectious materials.[6] Multiple dental professionals at the School and Hospital of Stomatology, Wuhan University, Wuhan, China, have contracted COVID-19, but it is unclear whether these infections were due to community transmission or transmission associated with oral health care delivery.[7] Developing a fuller understanding of the risks to patients and practitioners related to transmission during oral health care delivery and assessing mitigation strategies within the dental office are key components of improving patient safety and access to ongoing oral health care in this pandemic environment.

With the emergence of this novel virus and the ensuing pandemic, dentists have worked to establish guidance for practices to ensure the safety of practitioners, staff members, and patients. As early as March 2020, *Journal of Dental Research* published the infection control guidelines that dentists at Wuhan University used,[7] and, in April and May 2020, the American Dental Association (ADA) and the Centers for Disease Control and Prevention (CDC), respectively, released interim guidance on infection control protocols and changes to the practice and office environments.[8,9] These guidelines and other local interim guidance documents broadly agree, but the degree to which the US dental profession is aware of and adheres to these recommendations remains unknown. Furthermore, baseline data evaluating infection rates among dentists throughout the US are not widely known because CDC surveillance groups dental professionals with all other health care personnel.[10]

As far as we are aware, this is the first longitudinal study designed to track infection control practices and infection rates among US dentists. In this article, we used the first month of study data to estimate the prevalence of COVID-19 among US dentists and to determine the rate of compliance with CDC and ADA infection prevention and control procedures.[8,9]

METHODS

We administered a web-based survey using Qualtrics survey software (Qualtrics) from June 8 through June 12, 2020. US-based dentists were invited to participate in the survey if they held a license to practice dentistry in the United States, were in private practice or public health, and if, in a May 2020 ADA survey,[11] they reported that they would be willing to participate in a study on symptoms, testing, or diagnosis of COVID-19. In total, 5,479 dentists received an invitation to participate in the survey on June 8, 2020; a reminder invitation e-mail was sent June 11, 2020.

Participating dentists read and signed an electronic informed consent before participating in our study. The 18-question survey was constructed for this research. Demographic survey questions included birth year, race and ethnicity, gender, primary practice location, and dental specialty. SARS-CoV-2 infection was ascertained via self-reported date, type, and positive result of a SARS-CoV-2 test (confirmed case) or, if not tested, the date a health care provider informed the respondent that they had a probable SAR-CoV-2 infection (probable case). On the basis of these questions, and excluding those awaiting test results or with inconclusive results, COVID-19 prevalence was estimated. Consistent with CDC surveillance, the test positivity rate was defined as the numbers of confirmed cases over the total number of tested cases.[12] The survey also asked respondents to identify symptoms experienced in the past month (defined as since May 8, 2020), health conditions associated with COVID-19 severity,[13] and dental and nondental activities in the past month.

Because stressful events such as a pandemic can affect mental well-being, the validated Patient Health Questionnaire-4 screened respondents for depression or anxiety.[14,15] Respondents who reported providing oral health care in the past month were asked about infection prevention or control procedures in their primary dental practice. Respondents indicated which personal protective equipment (PPE) they used when treating patients in the past month and whether they used it sometimes or always. The CDC interim guidance document was used to categorize PPE use,[8] and respondents were categorized as following PPE guidance for AGDP if, in addition to basic clinical PPE of gloves and protective clothing, they "always" wore an N95 or similarly protective respirator (also called an "N95 mask") with eye protection, or the highest level of surgical face mask available with a full-face shield. Dentists who performed no AGDP were categorized as following PPE

ABBREVIATION KEY

ADA: American Dental Association.
AGDP: Aerosol-generating dental procedure.
CDC: Centers for Disease Control and Prevention.
FQHC: Federally qualified health center.
OSHA: Occupational Safety and Health Administration.
PPE: Personal protective equipment.
SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2.

Table 1. Characteristics of the survey sample and comparison with all private practice or public health dentists licensed in the United States.

CHARACTERISTIC	UNWEIGHTED SAMPLE, % (NO.) (N = 2,195)	ADA* MASTERFILE OF US DENTISTS, % (NO.) (N = 185,587)	χ^2 *P* VALUE
Age Group, y	NA†	NA	< .001
27-39	15.6 (343)	26.6 (49,326)	NA
40-49	23.2 (509)	23.4 (43,331)	NA
50-59	26.8 (589)	21.2 (39,253)	NA
60-69	27.4 (601)	20.9 (38,853)	NA
70-84	7.0 (153)	7.7 (14,355)	NA
Race and Ethnicity	NA	NA	< .001
Non-Hispanic white	79.2 (1,739)	71.4 (97,831)	NA
Non-Hispanic Asian	7.2 (159)	15.6 (21,412)	NA
Hispanic or Latino	5.2 (114)	5.6 (7,670)	NA
Non-Hispanic Black	1.1 (24)	4.7 (6,402)	NA
American Indian or Alaska Native	0.2 (5)	0.3 (459)	NA
Native Hawaiian or Pacific Islander	0.2 (4)	0.2 (286)	NA
Other	6.8 (150)	2.1 (2,938)	NA
Gender	NA	NA	< .001
Male	60.0 (1,294)	66.2 (121,125)	NA
Female	39.0 (841)	33.8 (61,847)	NA
Prefer not to say	1.0 (22)	NR‡	NA
Dental Practice Type			NA
Private practice	96.6 (2,077)	NR	NA
FQHC§	2.6 (56)	NR	NA
Non-FQHC health center	0.4 (8)	NR	NA
City or county health department	0.5 (10)	NR	NA
Practice Type	NA	NA	< .001
General dentist	83.6 (1,798)	79.2 (145,557)	NA
Dental anesthesiology	0.1 (2)	0.03 (48)	NA
Endodontics	1.6 (34)	2.7 (5,043)	NA
Oral and maxillofacial pathology	0.05 (1)	0.2 (283)	NA
Oral and maxillofacial surgery	2.6 (58)	3.5 (6,460)	NA
Oral medicine	0.1 (2)	NR	NA
Orofacial pain	0.1 (2)	NR	NA
Orthodontics and dentofacial orthopedics	2.0 (44)	5.4 (9,980)	NA
Pediatric dentistry	6.7 (147)	4.2 (7,751)	NA
Periodontics	2.3 (50)	2.7 (5,004)	NA
Prosthodontics	0.6 (14)	1.6 (3,025)	NA
US Census Bureau Division	NA	NA	< .001
New England	6.2 (136)	5.3 (9,849)	NA
Middle Atlantic	11.9 (262)	14.4 (26,709)	NA
East North Central	18.6 (409)	13.7 (25,439)	NA

* ADA: American Dental Association. † NA: Not applicable. ‡ NR: Not recorded. § FQHC: Federally qualified health center. ¶ Multiple conditions per person allowed.

Table 1. Continued

CHARACTERISTIC	UNWEIGHTED SAMPLE, % (NO.) (N = 2,195)	ADA* MASTERFILE OF US DENTISTS, % (NO.) (N = 185,587)	χ^2 *P* VALUE
West North Central	9.6 (211)	5.7 (10,644)	NA
South Atlantic	14.9 (327)	17.7 (32,758)	NA
East South Central	4.3 (95)	4.5 (8,253)	NA
West South Central	7.9 (174)	10.5 (19,456)	NA
Mountain	10.1 (221)	7.2 (13,423)	NA
Pacific	15.4 (337)	20.3 (37,606)	NA
Territories	1.0 (23)	0.7 (1,282)	NA
Conditions[¶]	NA	NA	NA
Asthma	7.3 (160)	NR	NA
Chronic lung disease	0.1 (3)	NR	NA
Diabetes	3.6 (80)	NR	NA
Heart condition	5.3 (116)	NR	NA
Immunocompromised	1.0 (22)	NR	NA
Kidney disease	0.5 (11)	NR	NA
Liver disease	0.3 (6)	NR	NA
Obesity	7.6 (166)	NR	NA
Rheumatologic or autoimmune condition	3.0 (65)	NR	NA
Smoking	1.2 (26)	NR	NA

guidance if they "always" wore gloves, protective clothing, a surgical mask, and eye protection. Occupational Safety and Health Administration guidance was used to categorize the risk of transmitting SARS-CoV-2 to dental providers or patients.[16] Finally, respondents who reported wearing respirators or masks were asked how often they changed them. The ADA Institutional Review Board approved the research protocol and survey, which are registered at ClinicalTrials.gov (NCT04423770).

All statistical analysis was conducted in Stata software, Version 14.0 (StataCorp). For COVID-19 prevalence, statistical weighting was performed using linearization variance estimation so that the sample appropriately represented licensed US dentists in private practice or public health according to age group and US Census Bureau division. The weights and information on age, race or ethnicity, gender, dental specialty, and US Census Bureau division for all licensed US dentists in private practice or public health came from the ADA master file of all dentists (ADA members and nonmembers) in the United States. Dentist records are updated weekly through state licensure databases, death records, ADA surveys of dentists, and other sources. The data used for weighting in our study were extracted from the ADA master file on June 25, 2020. Differences between continuous variables were tested using analysis of variance and between categorical variables using χ^2 tests, with statistical significance set at .05. Single and multivariable logistic regression models were used to test for associations between age category, race or ethnicity, gender, dental practice type, dental specialty, medical conditions, and confirmed or probable SARS-CoV-2 infection. Due to complex survey question skip patterns and because respondents were able to skip any question or stop answering the survey at any time, not all respondents answered all questions. The percentage of missing answers ranged from 2.0% through 3.5% per question.

RESULTS

Participant characteristics

A total of 2,195 US dentists representing all 50 states and Puerto Rico participated in the web-based survey June 8, 2020 through 12, 2020 (response rate, 40.1%). Median age of responding dentists was 54 years (range, 27-84 years) (Table 1). Overall, most respondents identified as male (59.9%), non-

Table 2. Dentists' self-reported symptoms and activities outside of their households in the month before survey administration.

SYMPTOMS/ACTIVITIES	UNWEIGHTED SAMPLE, % (NO.) (N = 2,195)
Symptoms	
Chills	0.9 (19)
Dry cough	2.6 (58)
Fever	0.7 (16)
Headache	9.0 (197)
Muscle pain	4.2 (92)
New loss of taste or smell	0.4 (9)
Repeated shaking with chills	0.1 (3)
Sore throat	3.1 (69)
Shortness of breath or difficulty breathing	1.2 (26)
Fatigue or malaise	4.0 (87)
Other	1.7 (38)
Patient Health Questionnaire-4 Screening	
Likely anxiety	19.5 (414)
Likely depression	8.6 (183)
Activities	
Provided emergency oral health care	91.1 (1,999)
Provided elective oral health care	80.1 (1,758)
Attended a health care visit for myself or a companion	27.3 (599)
Met in person with anyone outside your household	81.6 (1,791)
Met with a group of 10 or more people in a social setting	19.5 (428)
Attended any public event with 50 or more people	4.7 (103)
Traveled via taxi, ride share, or public transportation	2.7 (60)
Had contact with anyone with suspected or confirmed COVID-19	4.6 (100)

Hispanic white (79.2%), in private practice (96.6%), and with a focus on general dentistry (83.6%). Approximately one-fourth of the respondents (24.4%, n = 536) had at least 1 medical condition associated with a higher risk of developing severe illness from COVID-19.[13] The most common conditions were asthma (7.3%) and obesity (7.6%). Compared with all dentists licensed in the United States in private practice or public health, higher proportions of survey respondents were aged 40 through 69 years, and fewer were 39 years or younger and 70 years or older (Table 1). Compared with dentists nationally, survey respondents were more likely to come from certain US Census Bureau divisions, be non-Hispanic white, female, or a general dentist.

Symptoms among dentists

Dentists were asked whether they experienced any symptoms in the month before the survey administration, regardless of whether they thought the symptoms were related to COVID-19; 82.2% (n = 1,805) had no symptoms in the past month. The most commonly experienced symptom was headache (9.0%, n = 197) (Table 2). In the 2 weeks before survey administration, 33.9% experienced at least mild psychological distress, defined as a score of 3 or higher on the Patient Health Questionnaire-4 (mean [standard error], 2.21 [0.06]). Among dentists, 8.6% (n = 183) scored 3 or higher on the depressive symptom questions (mean [standard error], 0.80 [0.03]), indicating potential major depressive disorder, which was a significantly lower proportion than in the US general population (24.3%) measured the same month ($P < .001$).[17] A total of 414 dentists (19.5%) scored 3 or higher on the anxiety symptom questions (mean [standard error], 1.42 [0.04]), indicating potential generalized anxiety disorder, a significantly lower proportion than in the general

Table 3. Self-reported infection prevention and control efforts by dentists who practiced in the month before survey administration.

INFECTION PREVENTION AND CONTROL EFFORTS	UNWEIGHTED SAMPLE, % (NO.) (N = 2,042)
Screen or Interview Patients for Known or Suspected Severe Acute Respiratory Syndrome Coronavrus 2 Infection Before Dental Appointment or Treatment	98.4 (2,010)
Check Patients' Temperatures With a Thermometer Before Dental Treatment	97.2 (1,985)
Check All Dentist and Staff Member Temperatures With a Thermometer at the Beginning of Their Shift	94.4 (1,927)
Disinfect Frequently Touched Surfaces and Materials, Such as Pens or Light Switches	98.9 (2,020)
Disinfect All Equipment in the Operatory Between Patients	99.1 (2,024)
Encourage Distance Between Patients, Such as Scheduling Appointments Farther Apart, Asking Patients to Wait Elsewhere, or Asking Patients Not to Bring Companions	98.9 (2,019)
Physical Protection in the Practice, Such as Erecting Barriers, Opening Windows, or Using Air Filters or Scrubbers	85.2 (1,740)
Provide Face Masks or Coverings to Staff Members	99.1 (2,024)
Provide Face Masks or Coverings to Patients	75.9 (1,550)
Other Efforts	
Preprocedural mouthrinse	12.0 (51)
Extraoral suction device	4.0 (17)

population (25.5%)[17] ($P < .001$). The Patient Health Questionnaire-4 is designed to indicate cause for additional evaluation only, not diagnosis.[14]

Activities outside the household

Dentists were queried about their activities during the period of May 8 through June 12, 2020. Most respondents (81.6%) met in person with someone outside their household in the past month (Table 2). However, few dentists reported gathering in groups, attending public events, or sharing transportation in the past month. Few respondents (4.6%) stated that they believed they had been in contact with someone with suspected or confirmed COVID-19 in the month before the survey. Of the respondents who reported such contact, most (53.0% [n = 53]) reported that the person with suspected or confirmed COVID-19 was a dental patient, another 20.0% thought someone they worked with in the past month had COVID-19.

Dental practice and infection control

During the established period of our study, 91.1% of respondents (n = 1,999) provided emergency oral health care and 80.1% (n = 1,758) provided elective oral health care (Table 2). Among the 2,042 dentists who had provided oral health care in the month before administration of the survey, 92.8% (n = 1,892) performed AGDPs. Enhanced infection prevention and control efforts were common; 99.7% of dentists reported practicing them in the past month (n = 2,189). Almost all practicing dentists reported disinfecting all equipment and surfaces that are commonly touched, checking staff members' and patients' temperatures, screening patients for COVID-19, encouraging distance between patients while waiting, and providing face masks to staff members (Table 3). The most common additional infection control efforts were staff members' masking (99.1%) and disinfecting the operatory between patients (99.1%). The less frequently reported infection control efforts were making physical changes to the practice (85.2%) or providing face masks to patients (75.9%; however, write-in responses indicate this may be due to some practices requiring patients to bring their own masks). Respondents could also describe the infection control efforts in their practices if not already listed. Most of these write-in responses fit into existing categories, except for preprocedural mouthrinses for patients (12.0% [n = 51]) and use of extraoral suction device during dental procedures (4.0% [n = 17]).

PPE

PPE use when treating patients was common; 99.6% of practicing dentists (n = 2,034) reported its use. For dental procedures not expected to produce aerosols, the CDC interim guidance

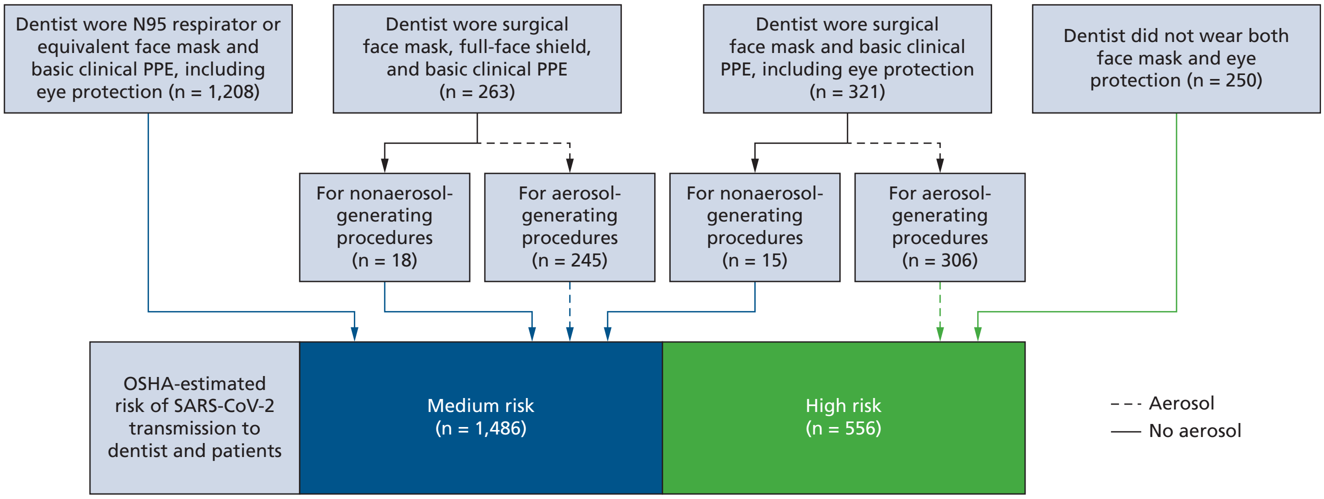

Figure. Personal protective equipment (PPE) always worn in past month, according to dental procedure. OSHA: Occupational Safety and Health Administration. SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2.

recommended surgical masks and basic clinical PPE, including eye protection.[8] Of the 146 dentists who reported performing non-AGDP in the past month, 82.9% (n = 121) always wore masks, basic clinical PPE, and eye protection (Figure). During AGDP with patients assumed to be noncontagious, interim guidance suggests use of a fitted N95 or equivalent mask and basic clinical PPE, including eye protection; 59.0% of dentists (n = 1,117) who reported performing AGDPs in the past month always wore this combination of PPE, and 61.6% (n = 90) dentists reported wearing this during non-AGDP. If N95 or equivalent masks are not available, the CDC interim guidance recommends using both the highest-level surgical face mask available and a full-face shield during AGDPs[8]; 12.9% of dentists (n = 245) performing AGDPs used this combination of PPE, as did 12.3% (n = 18) dentists during non-AGDP. In all, 72.8% (n = 1,486) of dentist respondents used PPE according to CDC interim guidance.[8]

During the time evaluated with this survey, there were limited supplies of PPE, particularly N95 or equivalent masks.[18] Some respondents (17.6%, n = 355) reported changing masks in between patients. More commonly, dentists changed masks between multiple patients (20.2%; n = 407), daily (34.2% , n = 689), weekly (7.7%, n = 155), or only if soiled or damaged (20.2%, n = 407). Respondents also wrote in to report that they used multiple masks simultaneously, with surgical masks worn over N95 or equivalent masks, and replaced the surgical masks more often.

Confirmed or probable COVID-19 among dentists

Among respondents, 16.6% (n = 355) reported that they had been tested for SARS-CoV-2 with at least 1 testing type. Fifty-one respondents (2.3%) were tested with 2 testing types—50 (2.3%) with both blood and nasal or throat swab tests and 1 (0.05%) with saliva and nasal or throat swab tests. A total of 244 respondents (11.1%) were tested with a nasal or throat swab, of which 9 (3.7%) tested positive. One hundred and fifty-six respondents (7.1%) were tested with a blood sample, and 4 (2.7%) had a positive result. Six respondents (0.3%) were tested for SARS-CoV-2 using a saliva sample and 0 had a positive result. Because testing was not widely available during this time, respondents were also asked whether they had received a diagnosis of probable COVID-19 infection and 7 (0.3%) had. Twenty dentists (0.9%) in this sample had either confirmed or probable COVID-19 cases. Weighted to approximate the age and location of licensed private practice and public health dentists nationally, the estimated prevalence of confirmed or probable COVID-19 among dentists was 0.9% (95% confidence interval, 0.5 to 1.5). The likely source of SARS-CoV-2 transmission was identified via contact tracing through a health agency or clinic in only 5 cases, and in none of those cases was the source of transmission the dental practice.

Association between COVID-19 and personal characteristics

Although respondents were tested for SARS-CoV-2 on dates ranging from March 6 through June 11, 2020, all but 1 positive test result came before the period the survey covered. The survey questions about symptoms, activities outside the household, dental procedures, and infection prevention or control efforts in their primary dental practice covered the past month only. This misalignment in timing precludes using these survey data to investigate modifiable and behavioral risk factors for COVID-19 among dentists. When we compared those with and without confirmed or probable COVID-19, there were no statistically significant differences in age, gender, race or ethnicity, underlying medical condition, dental practice type, dental specialty, or US Census Bureau division (all χ^2 $P > .2$). Given the limitations of antibody tests currently available in the United States,[19] a sensitivity analysis was conducted that excluded COVID-19 cases confirmed with antibody tests only. This analysis similarly found no statistically significant associations with age, gender, race or ethnicity, dental practice type, dental specialty, or US Census Bureau division (all χ^2 $P > .2$). However, there was a statistically significant association between antigen or viral confirmed or health care provider—suspected COVID-19 cases and patient-reported immunocompromised status. Specifically, 0.9% (n = 17) of COVID-19 negative dentists were immunocompromised compared with 6.3% (n = 1) of COVID-19 positive dentists (χ^2 $P = .02$).

DISCUSSION

Our study is the first to our knowledge to estimate SARS-CoV-2 infections in the US dental community and to assess the dental-related infection prevention and control efforts of dentists. In addition, this description of US dentists' dental practices and PPE use at 1 point can be useful to future understanding of the dental response to the pandemic and to assessing the results of future surveillance for COVID-19 prevalence. We estimated the infection rate of SARS-CoV-2 in US dentists. As of June 2020, an estimated 0.9% (95% confidence interval, 0.5 to 1.5) of US dentists have or have had COVID-19. This is similar to infection rates reported in health care workers in the Netherlands (0.9%)[20] and China (1.1%),[21] but lower than the rate in Seattle, Washington (5.3%).[22] Furthermore, in our sample, 3.7% of nasal or throat swabs tested positive, which is lower than the 10.3% positivity in respiratory specimens from the broader US population from March 1, 2020 through June 13, 2020.[23] This might reflect the higher socioeconomic status of many dentists and their subsequent ability to use social distancing and mitigate viral exposure.

The responses to our survey indicated that 99.7% of dental offices were using enhanced infection protection and control practices and many had also adopted advanced PPE. The reports from dentists of mask reuse or combined use of surgical masks and respirators might reflect the current CDC guidance regarding optimization of PPE due to supply issues.[8] As of June 29, 2020, patient volume in dental practices nationwide was estimated to be 70% of pre—COVID-19 levels, and it has been increasing steadily.[11] Use of disposable products for PPE and infection control might increase if patient volume increases, which could result in scarcity or alteration of practices within dental offices based on availability. In addition, changes in local and regional ordinances and infection rates might also alter practices within dental offices moving forward, particularly as COVID-19 cases resurge in many states.[24]

Although there were no significant demographic differences between COVID-19—negative and confirmed or probable cases, the COVID-19—positive group included more immunocompromised people. This relationship might reflect greater susceptibility in those people, a higher level of surveillance due to concern about underlying immune dysfunction, or the underlying mechanisms of viral binding and entry into host cells via angiotensin-converting enzyme 2.[25] Angiotensin-converting enzyme 2 is upregulated in the presence of certain systemic diseases.

To our knowledge, this is the first large-scale report of data surveilling rates of COVID-19 and concomitant infection protection and control practices among US dentists. The sample was generally representative of US dentists and large enough to allow for analysis of subgroups of interest. There are, however, limitations to these findings. The survey response rate of 40.1% was higher than the mean e-mail survey response rate of 24.0%,[26] but nonrespondents might differ from respondents, which can reduce the validity and generalizability of these results. The survey sample might also be subject to selection bias, leading to an underestimation of COVID-19 prevalence or severity because dentists who have died or been hospitalized with COVID-19, for example, cannot or might be less likely to participate. Due to the limited availability of COVID-19 tests in the United States,[27] it is possible respondents had limited access to COVID-19 testing and might have had undiagnosed infections. Furthermore, these findings are only as accurate as the COVID-19 tests and diagnoses themselves, which can be subject to false-negative and false-positive results.[28] There might be recall bias in the questions that asked about activities and symptoms in the past month. It is likely that respondents reported higher levels of social distancing and infection prevention and control compliance due to social desirability bias and unrecognized lapses in PPE usage. These cross-sectional data were also limited in that the timing of known SARS-CoV-2 infections in this survey sample precluded testing for associations with symptoms, activities, or infection prevention and control efforts.

Given that there is known community transmission of COVID-19, dentists might acquire COVID-19 in the community and outside of the delivery of oral health care. We attempted to use reports of contact tracing and infection timing to ascertain whether dentists were at increased infection risk owing to dental practice activities. The probable source of infection was not identified for most dentists in this sample (75.0% [n = 15]); for the remainder, contact tracing indicated community transmission. It should also be noted that disease spread during nonclinical activities within the dental office is also a potential transmission route and should be probed. In response to the COVID-19 pandemic, in March 2020 the CDC and ADA recommended that dentists postpone elective procedures.[8,29] Subsequently, the number of dental patients seen and procedures conducted in the United States dropped.[11] In this survey sample, 75.0% (n = 15) of dentists with presumed or confirmed COVID-19 tested positive in March or April, when 95% of US dental practices were closed or provided only emergency oral health care.[11] Subsequent surveys sent to the cohort described in our study will continue to collect COVID-19 test results, symptoms, activities, and infection prevention and control efforts in dental practices. Future research in this cohort might therefore be able to estimate COVID-19 incidence, as well as associations with dental activities and infection prevention or control efforts.

CONCLUSIONS

This survey was conducted to initiate surveillance of licensed, practicing dentists and public health dentists to determine the prevalence of COVID-19 before June 12, 2020, as well as the behavioral and infection control and prevention practices of dentists from May 8, 2020 through June 12, 2020. To our knowledge, this is the first study to estimate the prevalence of COVID-19 among US dentists. For this sample of dentists, the weighted prevalence of COVID-19 was 0.9%. Among the tested respiratory samples, 3.7% had positive results. These rates support that use of the CDC's currently recommended infection prevention and control procedures in dental offices will contribute to the reduced risk of developing infection during the delivery of oral health care, and risks associated with nonclinical activities and community spread might pose the most substantial risks for the exposure of dentists to COVID-19. Future investigations will assess ongoing rates of COVID-19 for US dentists and can assess modifiable risk factors for SARS-CoV-2 transmission and development of COVID-19 disease, in addition to defining incidence rates of disease. ■

SUPPLEMENTAL DATA

Supplemental data related to this article can be found at https://doi.org/10.1016/j.adaj.2020.09.005.

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1. Centers for Disease Control and Prevention. How COVID-19 spreads. Available at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html. Accessed June 12, 2020.

2. Kissler SM, Tedijanto C, Goldstein E, Grad YH, Lipsitch M. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science*. 2020;368(6493):860-868.

3. Prather KA, Wang CC, Schooley RT. Reducing transmission of SARS-CoV-2. *Science*. 2020;368(6498):1422-1424.

4. Wei WE, Li Z, Chiew CJ, Yong SE, Toh MP, Lee VJ. Presymptomatic transmission of SARS-CoV-2: Singapore, January 23-March 16, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(14):411-415.

5. Kutter JS, Spronken MI, Fraaij PL, Fouchier RA, Herfst S. Transmission routes of respiratory viruses among humans. Curr Opin Virol. 2018;28:142-151.

6. Harrel SK, Molinari J. Aerosols and splatter in dentistry: a brief review of the literature and infection control implications. *JADA*. 2004;135(4):429-437.

7. Meng L, Hua F, Bian Z. Coronavirus disease 2019 (COVID-19): emerging and future challenges for dental and oral medicine. *J Dent Res*. 2020;99(5):481-487.

8. Centers for Disease and Prevention. Guidance for Dental Settings: interim infection prevention and control guidance for dental settings during the coronavirus disease (COVID-19) pandemic. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html. Accessed June 29, 2020.

9. American Dental Association. ADA interim guidance for minimizing risk of COVID-19 transmission. Available at: https://web.archive.org/web/20200506114732/https://www.ada.org/~/media/CPS/Files/COVID/ADA_COVID_Int_Guidance_Treat_Pts.pdf?utm_source=cpsorg&utm_medium=covid-cps=virus-lp&utm_content=cv-pm-ebd-interim-response&utm_campaign=covid-19. Accessed May 6, 2020.

10. Centers for Disease Control and Prevention. CDC COVID data tracker: maps, charts, and data provided by the CDC—United States COVID-19 cases and deaths by state. Available at: cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html. Accessed August 26, 2020.

11. Health Policy Institute, American Dental Association. COVID-19 economic impact: survey results. Available at: https://www.ada.org/en/science-research/health-policy-institute/covid-19-dentists-economic-impact/survey-results. Accessed July 6, 2020.

12. Centers for Disease and Prevention. Coronavirus disease 2019 (COVID-19): cases, data, & surveillance—purpose and methods. Available at: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/purpose-methods.html. Accessed July 5, 2020.

13. Centers for Disease and Prevention. Coronavirus disease 2019 (COVID-19): people at increased risk—and other people who need to take extra precautions, people at increased risk for severe illness. Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-at-higher-risk.html. Accessed May 5, 2020.

14. Löwe B, Wahl I, Rose M, et al. A 4-item measure of depression and anxiety: validation and standardization of the Patient Health Questionnaire-4 (PHQ-4) in the general population. *J Affect Disord*. 2010;122(1-2):86-95.

15. Pfizer. Welcome to the Patient Health Questionnaire (PHQ) Screeners. Available at: https://www.phqscreeners.com/index.html. Accessed May 5, 2020.

16. US Department of Labor, Occupational Safety & Health Administration. COVID-19: control and prevention—dentistry workers and employers. Available at: https://www.osha.gov/SLTC/covid-19/dentistry.html. Accessed June 29, 2020.

17. Czeisler MÉ. Mental health, substance use, and suicidal ideation during the COVID-19 pandemic: United States, June 24-30, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(32):1049-1057.

18. Health Policy Institute, American Dental Association. COVID-19: economic impact on dental practices—week of June 1 results. Available at: https://surveys.ada.org/reports/RC/public/YWRhc3VydmV5cy01ZWQ2NjRiNzBhNzI3MTAwMGVkMDY2ZTQtVVJfNWlJWDFFU01IdmNDUlVO. Accessed July 6, 2020.

19. Centers for Disease Control and Prevention. Interim guidelines for COVID-19 antibody testing: interim guidelines for COVID-19 antibody testing in clinical and public health settings. Available at: https://www.cdc.gov/coronavirus/2019-ncov/lab/resources/antibody-tests-guidelines.html. Accessed July 15, 2020.

20. Kluytmans-van den Bergh MF, Buiting AG, Pas SD, et al. Prevalence and clinical presentation of health care workers with symptoms of coronavirus disease 2019 in 2 Dutch hospitals during an early phase of the pandemic. *JAMA Network Open*. 2020;3(5):e209673.

21. Lai X, Wang M, Qin C, et al. Coronavirus disease 2019 (COVID-2019) infection among health care workers and implications for prevention measures in a tertiary hospital in Wuhan, China. *JAMA Network Open*. 2020;3(5):e209666.

22. Mani NS, Budak JZ, Lan KF, et al. Prevalence of COVID-19 infection and outcomes among symptomatic healthcare workers in Seattle, Washington [published online ahead of print June 16, 2020]. *Clin Infect Dis*. https://doi.org/10.1093/cid/ciaa761.

23. Centers for Disease and Prevention. COVIDView summary ending on June 13, 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/past-reports/06192020.html. Accessed July 6, 2020.

24. Johns Hopkins University & Medicine. Coronavirus resource center: impact of opening and closing decisions by state—a look at how social distancing measures may have influenced trends in COVID-19 cases and deaths. Available at: https://coronavirus.jhu.edu/data/state-timeline. Accessed July 15, 2020.

25. Fang L, Karakiulakis G, Roth M. Are patients with hypertension and diabetes mellitus at increased risk for COVID-19 infection? *Lancet Respir Med*. 2020;8(4):e21.

26. Sheehan KB. E-mail survey response rates: a review. *J Comput Mediat Commun*. 2001;6(2).

27. Ketchum K, O'Connor L. COVID-19 testing problems started early, U.S. still playing from behind. Available at: https://www.modernhealthcare.com/technology/covid-19-testing-problems-started-early-us-still-playing-behind. Published May 11, 2020. Accessed July 6, 2020.

28. Woloshin S, Patel N, Kesselheim AS. False negative tests for SARS-CoV-2 infection: challenges and implications. *N Engl J Med*. 2020;383(6):e38.

29. Burger D. ADA recommending dentists postpone elective procedures. *ADA News*. March 16, 2020. Available at: https://www.ada.org/en/publications/ada-news/2020-archive/march/ada-recommending-dentists-postpone-elective-procedures. Accessed July 6, 2020.