Infection Risk of COVID-19 in Dentistry Remains Unknown: A Preliminary Systematic Review

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Background: COVID-19 is a novel viral respiratory disease caused by a member of the coronavirus family, SARS-CoV-2, and has been declared as a pandemic on March 2020. Dental practitioners are routinely exposed to infectious bodily excretions, for example, saliva, blood, and respiratory excretions. Therefore, they are in the first line of SARS-CoV-2 infection-prone health care providers. The purposes of the current review are to trace documented cases of COVID-19 transmission inside dental settings worldwide and to explore the clinical management of these cases.

Methods: We searched MEDLINE and Google Scholar for all possible reported cases of COVID-19 transmission in dental practice as of December 1, 2019, until May 13, 2020. Multiple terms and combinations were used, including "coronavirus," "COVID-19," "SARS-CoV-2," "dental," "dentistry," "transmission," and "nosocomial." Articles that were not written in English were excluded.

Results: A total of 78 articles were found from December 29, 2019, until May 13, 2020. Of these, 31 articles discussed the risks related to dental practice and recommended infection management protocols for dental health care personnel. Of these articles, only 1 had reported data on transmission of COVID-19 in dental practice. Two possible transmissions of COVID-19 to dental personnel were reported in China before its recognition as an epidemic.

Conclusions: Although it seems that there are almost no reported cases of infection by SARS-CoV-2 during dental treatments, occupational or nosocomial transmission could not be ruled out. Hence, further prospective assessment of COVID-19 transmission is urgently required, and careful and protective measurements are necessary to avoid infection during dental practice.

Key Words: community dentistry, epidemiology, infection control, occupational dentistry, pandemics, virology

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Coronavirus disease (COVID-19) is a novel disease caused by a member of the coronavirus family that originated in Wuhan, Hubei, China, in December 2019.[1] This infectious agent was first named 2019-nCoV and then officially SARS-CoV-2 by the World Health Organization. Over the past few months, the infection has spread to 188 countries and regions worldwide. On March 11, 2020, the World Health Organization has declared COVID-19 as a pandemic because the number of cases reached more than 118,000.[2] As of May 13, 2020, there have been 4,291,081 laboratory-confirmed cases of COVID-19 worldwide, with 293,157 global deaths and 1,507,598 global recoveries.[3] Given the widespread transmission of SARS-CoV-2 and the reports of its spread to health care providers,[4] dental health care personnel (DHCP) are at most risk for nosocomial infection and can become potential carriers of the disease.[5,6]

SARS-CoV-2 effectively uses angiotensin-converting enzyme 2 receptor for cell invasion.[7] Angiotensin-converting enzyme 2 receptor was found to be expressed in the epithelium of the rhino-respiratory and parts of gastrointestinal tracts, as well as the bladder, myocardial cells, oral mucosa, gingival tissue, and salivary glands.[8,9] Because salivary gland epithelial cells share the angiotensin-converting enzyme 2 receptor, saliva might potentially become a major source of the virus.[10] Even after patient recovery, recurrence during the convalescence period was reported.[11] This is plausible because the presence of some virus strains in saliva for as long as 29 days has been reported in the literature.[12,13] The viral loads of SARS-CoV-2 in various human specimens were reported as following: anterior nasal mucosa, 6.1 $\log_{10}$ copies/mL[14]; oropharynx, 5.2 $\log_{10}$ copies/mL[15]; nasopharynx, 5.4 $\log_{10}$ copies/mL[16]; and saliva, 4.1 $\log_{10}$ copies/mL.[16] The minimum infectious dose for SARS-CoV-2 is yet unknown but guessed to be a few hundreds of virions.[17]

Human-to-human transmission of COVID-19 is now believed to be mainly via saliva-associated respiratory droplets and contact transmission. Saliva droplets are generated when breathing, talking, coughing, or sneezing and are formed as particles of moisture and droplet nuclei of microorganisms.[18] Large droplets and splatter (diameter >50–60 μm) tend to fall ballistically to the ground, so the risk of pathogen transmission is limited to individuals in close proximity to the infector (1–2 m).[19,20] Small droplets (diameter ≲50 μm) are likely to evaporate into droplet nuclei (diameter <10 μm), which sustain in the air for protracted periods, and then become potentially transmitted by air flow over a longer distance as aerosol.[18,21] After being suspended in the air, the droplets and aerosol continue to pose a risk by settlement on environmental surfaces.[8]

COVID-19 might be disseminated by many routes, most of which are, unfortunately, very common in the daily dental practice. Dental and oral surgery drills, as well as ultrasonic devices and the triple syringe, form aerosol and splatter, which are commonly contaminated with bacteria, viruses, fungi, and blood.[22–25] Moreover, as validated by numerous studies, strong evidence indicates that the severe acute respiratory syndrome virus (SARS) spreads through aerosol transmission.[26]

Although not completely understood at this stage, aerosol and fomite transmission of SARS-CoV-2 is plausible as the virus can remain viable and infectious in aerosols for at least 3 hours and on surfaces for days.[27,28]

There is an increasing body of evidence to suggest that human-to-human transmission rate from asymptomatic patients (4.1%) is statistically similar to that from symptomatic patients (6.3%).[29] Alarmingly, emerging data from European countries and the United States point to very high proportions of asymptomatic COVID-19 carriers, estimated to range from 25% to 50% of all confirmed cases. Therefore, asymptomatic and presymptomatic patients are both major sources of SARS-CoV-2 transmission, as they are covert and show no warning signs to health care workers or laypersons at the time of contact.[30] The high airborne infectiveness of SARS-CoV-2 was demonstrated by COVID-19

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outbreak on March 2020 in Skagit country, Washington, United States. After a 2.5-hour choir practice attended by 61 persons, 1 minimally symptomatic choir member transmitted SARS-CoV-2 to as many as 52 other choir members even though most of the people were at least 2 m apart.[31]

There are currently no data available to validate the level of risk of SARS-CoV-2 transmission during dental practice, nor literature to support whether DHCP are adequately protected by current proposed protective equipment.[5] Necessarily, the purposes of the current article are to review documented transmission of COVID-19 in dental settings and to review the reported risks of COVID-19 transmission to DHCP and to visitors of dental facilities.

MATERIALS AND METHODS

We conducted a comprehensive literature search, using MEDLINE and Google Scholar, to find all possible reported cases of any form of COVID-19 transmission in dental practice. The search covered the period from December 1, 2019, until May 13, 2020. We used a combination of the following search terms: (coronavirus or COVID-19 or SARS-CoV-2) with (dentistry or dental) with (transmission or nosocomial). Because the available clinical data on COVID-19 transmission in dental settings are scarce, all articles that matched the search terms were full-text retrieved. The terms "transmission" and "nosocomial" as well as "contract," "contagion," "infect," and "case" were sought in the text of each article with the purpose of identifying documented cases of COVID-19 transmission in dentistry. Moreover, each article was sought for any other appropriate relevancy. Efforts were made to exclude from Google Scholar articles that were already retrieved by MEDLINE, to avoid an overlap between results. Non-English written articles were excluded; however, their abstracts were examined for relevancy.

RESULTS

A total of 78 articles matched the search terms and were included in the current review (Fig. 1). Ten articles were not relevant to dentistry. These irrelevant articles incidentally appeared on search because of inclusion of the word "dentistry" in the affiliation of their authors or because "dentistry" or "dental" were encountered for some other reasons. There were 62 articles that were relevant to either dentistry or oral surgery fields and were full-text retrieved and further analyzed and traced for reports on COVID-19 transmission. Only 1 article had an actual report on COVID-19 transmission in dental practice. All possible relevant data on COVID-19 transmission that were retrieved from all the analyzed articles are summarized in Table 1.

DISCUSSION

The current article has systematically reviewed literature available on COVID-19 transmission in dental settings and found no reported cases of transmission since its declaration as a pandemic. Also, no experimental or epidemiological studies considering dental occupational COVID-19 transmission were found. Meng et al anecdotally reported 9 cases of COVID-19 transmissions to DHCP who were using standard precautions in China, before quarantine on Wuhan region was imposed.[32] Of these 9 cases, only 2 could not be excluded to be caused by occupational

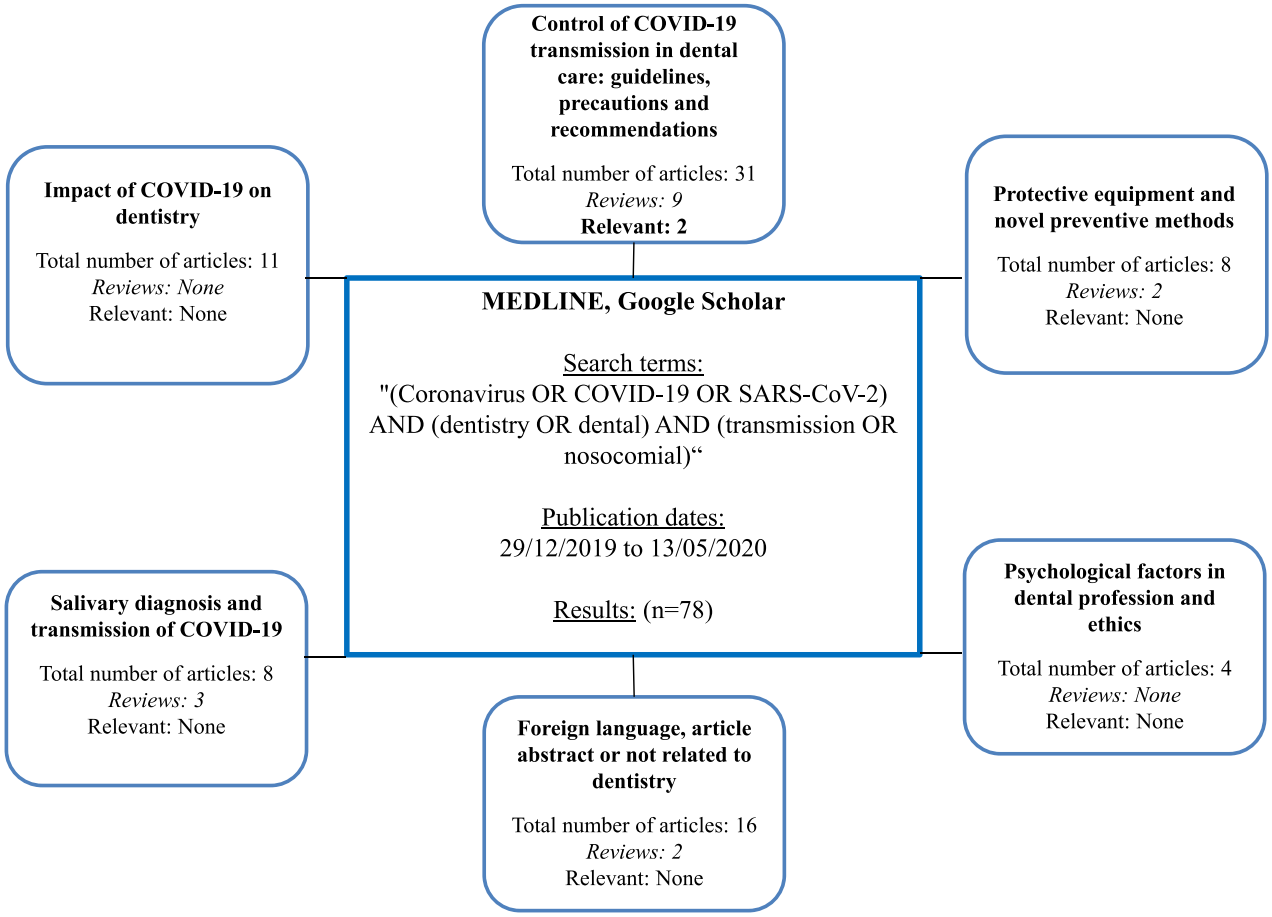

FIGURE 1. Systematic search results classified according to topics and relevancy.

TABLE 1. Summary of All Available Data From 62 Full-Text Retrieved Articles on Documented COVID-19 Transmission in Dentistry

Author, Country, Reported Range of Dates	Number of DHCP; Number of Treated Patients	Risk of COVID-19 Transmission	Kind of Protection	Confirmed Occupational Transmission of COVID-19	Comments
Meng et al, China. December 30, 2019–January 22, 2020 (before lockdown on Wuhan city and before regulations on dental services)	Potentially: 1098 staff members, 898 students; ~57,000 outpatients	General public, no COVID-19 screening	Standard precautions: medical masks and gloves	9 staff members were infected overall: 3 doctors 3 nurses 2 administrative workers 1 postgraduate student	According to epidemiologic investigation and medical history, all these 9 cases, except 2 nurses from the same department, are unlikely to result from COVID-19 cross-infection in the dental facilities.
Meng et al, China. January 24, 2020–February 25, 2020	169 DHCP >700 emergency dental care patients	*"Orange clinic"*: Nonsuspected patients. *"Red clinic"*: 1. Suspected or recovering patients from COVID-19 2. Droplet/aerosol producing procedure in either patient	*"Orange clinic"*: Disposable N95 masks, gloves, gowns, cap, shoe cover, and goggles or face shield. The area is disinfected once every half day. *"Red clinic"*: Addition of protective suits, area disinfection immediately after treatment. No negative pressure rooms	None infected	–Goggles and protective suits were not available until January 28, 2020 –All patients and their accompanying persons were requested to provide their telephone number and home address in the case that either DHCP or patients are suspected or confirmed with COVID-19 in the future.

Izzotto et al, Italy. March 2020 – April 7, 2020	Not specified	1. Subjects with known SARS-CoV-2 infection 2. Subjects at potential risk of infection 3. Subjects with unknown risk of infection 4. Subjects who have healed from COVID-19.	*Patient triage:* Phone-designated questionnaire *Patient entrance into the clinic:* Retake history Temperature <37.5 Hand hygiene Ventilation system disinfection Windows are frequently opened Reorganization and disinfection of waiting room to prevent cross-infection No accompanies Mouth rinse before treatment *Dental treatment:* Careful hand washing by dental practitioner before wearing gloves Face masks (level 2 or 3) for all staff Protective safety glasses and shields All necessary instruments have been prepared in advance Disposable protection over surfaces, dental chair, and devices Rubber dam Surgical aspiration Manual instruments are preferred to handpiece Limit contact with patient to <15 min *After treatment:* All disposable protections are removed 5-min air change during which do not remove PPE Disinfection of goggles and shield Repeat hand hygiene	–Not able to suggest which protection equipment to use when treating patients with COVID-19 –No report whether COVID-19 has actually had been transmitted

DHCP indicates dental health care personnel; PPE, personal protective equipment.

TABLE 2. The Longest Reported Duration of Viral Viability of SARS-CoV-2 and Other Human Coronaviruses on Various Surfaces Over Time

Material	Time to SARS-CoV-2 Decay Below Detection Limit	Longest Reported Viable Human Strain Other Than SARS-CoV-2		Examples in Dental Care
Metals				
Stainless steel	48 h[24] 7 d[23]	5 d[39]	HCoV-229E	Hand and rotating instruments
Copper	4 h[24]	<40 min[40]	HCoV-229E	Bur cleaning brush Dental Amalgam (as alloy)
Aluminum	Not reported	8 h[39]	HCoV-229E HCoV-OC43	Endo ruler Bur holder
Zinc	Not reported	120 min[40]	HCoV-229E	Dental Amalgam (as alloy)
Natural polymers				
Cardboard	24 h[24]	Not reported		Packages
Wood	2 d[23]	4 d[39]	SARS-CoV-P9	Wedges Bite stick
Paper	3 h[23] (printing and tissue paper)	5 d[39]	SARS-CoV-P9	Questionnaires and forms
Synthetic polymers				
Plastic	72 h[24]	9 d[39]	SARS-CoV-FFM1	Dental unit handles and control panel Dispensers
Polyvinyl chloride (PVC)	Not reported	5 d[39]	HCoV-229E	Saliva ejector Vacuum suction pipe
Silicon rubber	Not reported	5 d[39]	HCoV-229E	Polishing burs Mixing cups Handpiece tubing
Teflon (Polytetrafluoroethylene)	Not reported	5 d[39]	HCoV-229E	Dental tape
Others				
Glass	4 d[23]	5 d[39]	HCoV-229E	Mixing plate Light cure tip
Ceramic	Not reported	5 d[39]	HCoV-229E	Porcelain fused to metal crowns
Surgical latex glove	Not reported	8 h[39]	HCoV-229E HCoV-OC43	–
Disposable gown	Not reported	2 d[39]	SARS-CoV-GVU6109	–
Mask, inner layer	7 d[23]	Not reported		–
Mask, outer layer	>7 d[23]	Not reported		–
Cloth	2 d[23]	Not reported		–
Banknote	4 d[23]	Not reported		–

exposure after epidemiological investigation. Izzetti et al[33] reported the measures of COVID-19 prevention in Italy; however, they could not conclude whether these measures were efficient enough to prevent COVID-19 transmission. Also, they did not report if any transmission had actually occurred. These findings are surprising, knowing that health care workers were highly infected with COVID-19, as documented in numerous studies.[34–36]

The absence of documented cases of COVID-19 transmission in dental practice since its recognition as a pandemic should be interpreted with great caution, as dental practitioners appear on worldwide reports of deaths from COVID-19. As of May 12, 2020, Medscape honored 1012 health workers who have already died of COVID-19, regardless whether they were practicing and whether infection control tracing was done.[37] Of them, 22 were DHCP: 20 dentists, 1 dental nurse, and 1 dental technician; 13 dentists were from Italy and 7 were aged 48 to 78 years (with an average of 66 years) (the age of the other 6 dentists was not reported). As of March 2019, most dentists in Italy were aged 20 to 60 years (88.88%).[38,39] The mortality rate in this age group from COVID-19 is much lower (0.1%–2.7%) than in the general population of Italy (13.7%).[40] This may explain why only 13 dentists were reported to die of COVID-19, but this may also lead to an alarming possibility that a much higher number of dentists were infected but not reported, despite very high level of personal protective equipment (PPE) adopted in Italy (Table 1). Although Medscape's report includes cases of death not directly resulting of COVID-19, still, these data strongly suggest that at least several dentists might have contracted COVID-19 during dental practice. However, in the clinical setting of a dental practice, droplet exposure is so prevalent that the number of deaths might have been underreported.

Past evidence has shown that most of SARS-CoV and MERS-CoV cases were associated with nosocomial transmission in hospitals, resulting, partly, from use of aerosol-generating procedures performed on patients with respiratory diseases.[41] Interestingly, it is reassuring that, to date, there have been no documented cases of SARS transmission in dental settings. This can result from several factors, unique for SARS and MERS, but absent in COVID-19; first, SARS and MERS transmission has not been

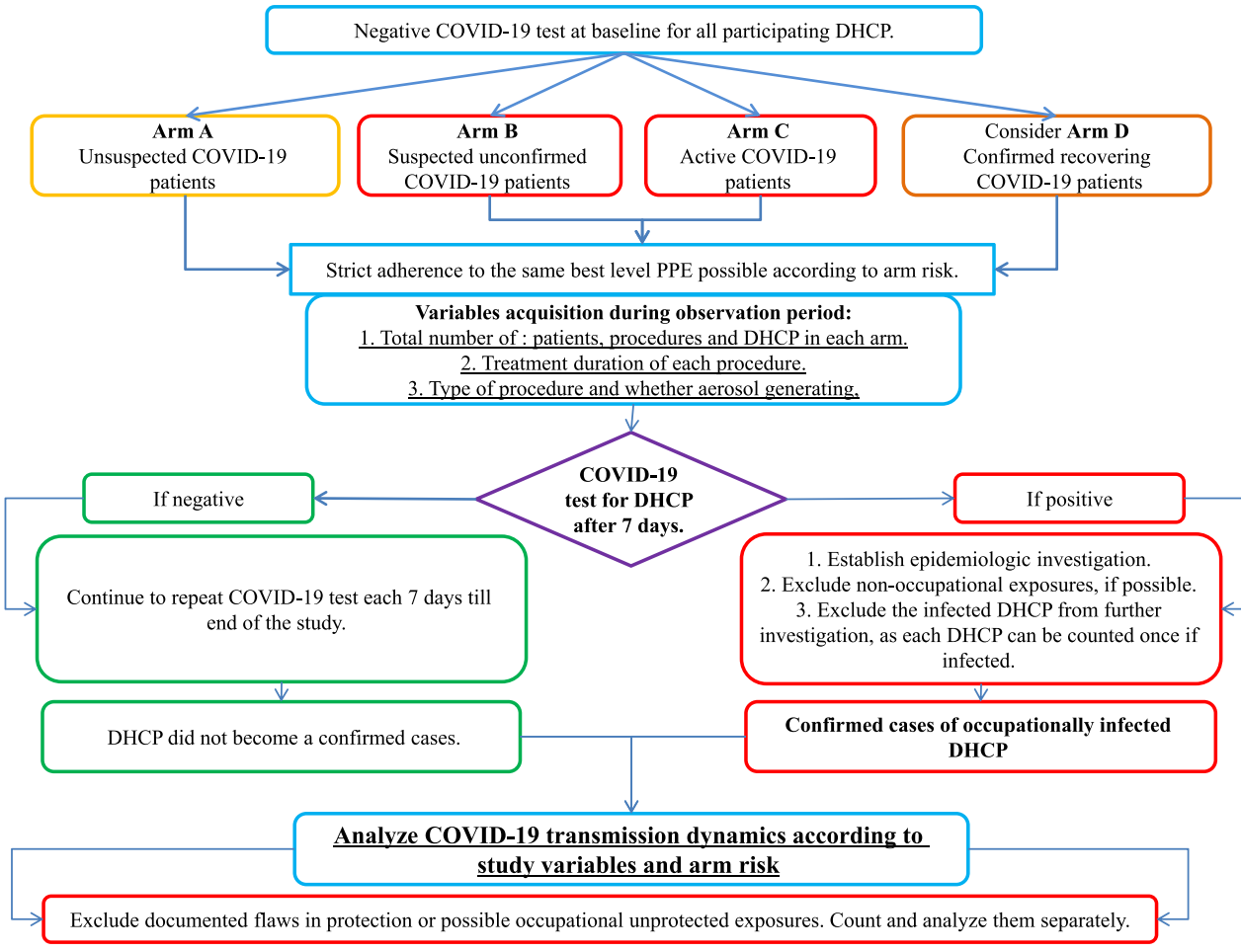

FIGURE 2. Tentative prospective cohort study protocol for assessment of COVID-19 transmission dynamics in dental health care settings through estimates of the secondary infection rate among DHCP, risk factors for infection, effectiveness of PPE, and possible routes of transmission.

documented during the incubation period before febrile symptoms. Second, it is unlikely that patients with SARS or MERS would visit a dentist for an elective treatment while they were in the acute phase of the disease, because of high fever and other, rather debilitating, attendant symptoms.[42] Third, based on current epidemiological data, COVID-19 has higher transmissibility than SARS-CoV and MERS-CoV,[11] with up to 44% of COVID-19 transmissions occurring at the presymptomatic stage.[43] Hence, it is plausible that COVID-19 transmission would occur in dental settings, unlike past evidence with SARS and MERS.

Several techniques are aimed at preventing COVID-19 transmission in dental settings. These techniques include the use of best possible PPE, allowing fresh air in between patients, meticulous hand hygiene, and sterilization procedures aimed at inactivating, destroying, or removing pathogens from any surface or instruments.[20] Because small particles in aerosol might remain suspended in indoor environments for 3 to 4 hours, a good ventilation or air conditioning system in dental offices may be as important as PPE. In addition, COVID-19 screening questionnaires are completed and patient's body temperature is measured before any dental visit. In cases other than emergencies, all patients with any symptom consistent with COVID-19, positive testing, or potential previous exposure are deferred for at least 2 weeks.[4] Previsit screening of COVID-19 by nasal swab or antibody analysis was also suggested.[44] Control of fomite transmission of SARS-CoV-2 presents a tremendous challenge in dentistry because of a combination of high variety of materials commonly used in dental routine, with a prolonged and variable temporal decay of the viral inoculum (Table 2).[23,24,45,46] Inadequate disinfection of surfaces or unnoticeable contamination of dental supply (ie, secretions, aerosol) presents an additional unexpected threat of COVID-19 transmission. However, the existing data on surface persistence are based on experimental conditions only and do not necessarily reflect all clinical situations, particularly in dentistry.

To date, the most common strategy to manage suspected COVID-19 transmission in dental practice was to quarantine the potentially infected persons for as long as 14 days and to report health authorities. This may also be referred to as the "watch and see" strategy, unlike very dedicated guidelines of assessment and prevention in cases of exposure to other well-known infectious agents, like HIV.[47] A more dedicated risk assessment should be adopted, based on clinical experience and evidence of COVID-19 transmission. Therefore, an urgent need for systematic collection, analysis, and publication of the exact occurrence of COVID-19 transmission in dentistry is required. Similar demand on analysis and publication of COVID-19 transmission and death cases in other

health care workforces was already highlighted.[35] For this reason, we propose a tentative prospective protocol for tracing COVID-19 transmission in dental settings (Fig. 2).

CONCLUSIONS

The risk of a dental practitioner being positive for COVID-19 and potentially infecting patients, accompanies, and other DHCPs should not be underestimated. The theoretical risk of SARS-CoV-2 transmission in dentistry is significant and justifies fairly stringent airborne precautions. A constant source of COVID-19 infection in dental settings might create a micro epicenter with many potential infectees, until the source is traced through epidemiological investigation. According to the current available evidence, the potential risk to DHCP from occupational exposures has not been adequately assessed by epidemiologic studies in health care setting and should be further investigated.

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