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ORIGINAL ARTICLE

Retrospective study on the effectiveness of a prevention strategy in a dental hospital during the COVID-19 pandemic

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Abstract

Objectives To evaluate the effectiveness of a prevention strategy against the spread of SARS-CoV-2 infection among dental hospital staff over a 3-month period.

Materials and methods The effectiveness of the prevention strategy, which adopted healthcare staff protective measures, including patient triage and correct usage of personal preventive equipment, was evaluated by SARS-CoV-2 detection and serological testing. Patients who visited the Affiliated Stomatology Hospital, Zhejiang University School of Medicine, Hangzhou, China, between January 31 and March 1 (lockdown period) and March 2 and April 27 (reopening period) in 2020 and in the same period in 2019 were included in the study. Patients' diagnosis, age, gender, and several undergoing aerosol-generating procedures during the study period were collected from the hospital's database. Corresponding data were compared year-on-year (2020-on-2019). A total of 757 hospital staff underwent SARS-CoV-2 detection and serological testing on April 28–29, 2020.

Results During the lockdown and reopening period in 2020, the number of hospital visits was dramatically decreased to about 6% and 58%, respectively, compared with the same period in 2019. However, emergency visits were increased 16- and 6.4-fold. A total of at least 6654 patients (13.58%) underwent aerosol-generating procedures during the study period in the year 2020. All hospital staff were negative according to SARS-CoV-2 detection and serological testing (IgG, IgM) data.

Conclusion During the study period in 2020, the total number of hospital visits dramatically reduced but emergency visits significantly increased. The prevention strategy implemented successfully prevented SARS-CoV-2 infection spread among healthcare workers in a dental hospital.

Clinical relevance The prevention strategy indicated patient triage and how to adopt preventive measures for controlling SARS-CoV-2 spread among healthcare workers. These data can be used as a reference for other sectors suffering from the COVID-19 pandemic.

Keywords COVID-19 · SARS-CoV-2 · Dental healthcare · Prevention strategy · Aerosols

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Introduction

The epidemic outbreak of coronavirus disease 2019 (COVID-19), originating in Wuhan, China, in December 2019, has rapidly evolved into a public emergency of international concerns and finally became a pandemic [1]. At present, human-to-human transmission of SARS-CoV-2 via close contacts has been confirmed, including direct transmission and contact transmission [2]. The direct transmission mode indicates that SARS-CoV-2 infection is attributable to transmission via droplet inhalation, in which droplets are produced by cough and sneeze [3]. Moreover, the contact transmission mode indicates that individuals can be infected by touching contaminated surfaces and involuntarily touching their own mouth, nose, or eyes [4, 5]. In addition, SARS-CoV-2 transmission has also been confirmed to occur via aerosols or the fecal-oral route [3, 6, 7].

Dentists and nurses face a high risk of infection since they are exposed to saliva, blood, droplets, and aerosols that are generated by high-speed handpiece and ultrasonic instruments that are routinely used in the dental clinic [8]. Except for emergency cases, routine dental clinic work was suspended in cities and countries in lockdown to reduce SARS-CoV-2 transmission, while non-lockdown cities and countries still provided routine dental procedures for regular patients [9, 10]. Asymptomatic COVID-19 cases have also been reported [11]. This has significantly increased the great risk of SARS-CoV-2 transmission among dental healthcare personnel [12, 13]. Hence, the public demand for dental care has been a challenge during the COVID-19 pandemic [9].

To control the COVID-19 pandemic, many countries have implemented social distancing, a cough etiquette, international travel restrictions, and quarantine of suspected cases, and international travelers coming from severe pandemic countries and territories [14]. Currently, several vaccine candidates are in phase 3 clinical trials, and their effectiveness is being evaluated [15]. Patients with mild COVID-19 symptoms, who are asymptomatic or pre-symptomatic, might seek dental treatment; therefore, preventive measures should be strictly implemented in dental hospitals [16, 17]. Healthcare staff protective measures are important during the COVID-19 pandemic [3].

Due to the COVID-19 epidemic outbreak in Zhejiang province, China, routine dental procedures were suspended from the end of January 2020 to March 1, 2020. Most dental clinics and hospitals in Hangzhou, China, were closed during the lockdown period from January 29 to March 1, 2020, and only emergency cases were treated. As of March 2, 2020, our province has gradually reopened. To date, a global consensus of an effective prevention strategy for preventing COVID-19 spread in dental hospitals and clinics has not been reached [8, 14]. We proposed a prevention strategy for controlling the COVID-19 spread in dental hospitals and clinics. The dental quality control center of the Zhejiang province popularized the prevention strategy in dental clinics and dental hospitals in the Zhejiang province. For qualitative detection of SARS-CoV-2, the World Health Organization has recommended reverse transcription polymerase chain reaction (RT-qPCR) testing on respiratory tract specimens [18]. Moreover, serological testing for specific anti-SARS-CoV-2 IgG and/or IgM has been recognized as important in assisting the diagnosis of COVID-19 [19].

The effectiveness of a standardized prevention strategy for preventing the COVID-19 spread should be sufficiently investigated [10]. Therefore, a retrospective study was performed to evaluate the effectiveness and significance of the prevention strategy for controlling the spread of SARS-CoV-2 among healthcare workers in a dental hospital over a 3-month period. The prevention strategy was adopted and strictly implemented by the Affiliated Stomatology Hospital, Zhejiang University School of Medicine (Hangzhou, China).

Materials and methods

Prevention strategy for controlling the spread of COVID-19

To prevent the spread of COVID-19 during dental procedures, a novel prevention strategy for halting the spread of COVID-19 among dental hospital staff was proposed. Healthcare staff protective measures before and during dental procedures are summarized in Table 1.

Patient triage was mainly performed according to temperature measurements and a questionnaire about the epidemiological history and cause of fever. This is detailed in Fig. 1.

Data source

All patients who visited the Affiliated Hospital of Stomatology, Zhejiang University School of Medicine (Hangzhou, China) between 31 January and 27 April 2020, as well as patients who visited the hospital in the corresponding period in 2019, were included in this retrospective study. According to COVID-19 epidemic spread in Zhejiang province, China, the epidemic spread period was divided into the lockdown and the reopening period. The lockdown period was from January 31, 2020, to March 1, 2020, during which only emergency patients were treated. The reopening period was from March 2 to April 27, 2020, when the COVID-19 outbreak had been controlled, during which regular dental procedures were resumed except for dental implant placement surgery, ultrasonic scaling, and tooth preparations for crown and bridge restorative procedures. Patients' data were obtained from the hospital's database and analyzed based on patients' gender, age, and diagnosis. Patients' diagnosis and

Table 1 The peri- and pre-operative preventive procedures in different situations

Staff in different situations	Peri-operative procedures													Pre-operative procedures
	Personal protective equipment (PPE)									Dental setting/device				
	Disposable head cap	Medical mask	Medical surgical mask	Medical protective mask[a]	Face shield/goggles	Working clothes[b]	Disposable/reusable preventive gown	Disposable latex gloves	Disposable shoe covers	Rubber dam	High-volume suction	Isolation room	Anti-retraction handpiece[c]	
Patient triage	●	●	○		●	●	○	●	/	/	/	/	/	Face mask Temperature measurement Questionnaire
Oral examination/-general treatment	●		●		●	●	●	●	/	/	○	◘	/	Preoperative mouth rinse[d]
Aerosol-generating procedures	●			●	●	●	●	●	●	◘	●	●	◘	
Laboratory	●	●	○		○	●	○	●	○	/	/	/	/	/
Radiology	●	●	○		○	●	○	○	/	/	/	/	/	
Medical instrument cleaners	●		●		●	●	●	●	○	/	/	/	/	
General cleaners	●	●	○		/	●	○	○	/	/	/	/	/	
Transporters of medical waste	●		●		○	●	○	●	○	/	/	/	/	
Security guards	○	●	○		○	●	/	/	/	/	/	/	/	

●: obligated; ◘: recommended but not obligated; ○: selection based on necessity; /: unnecessary

[a] It is recommended to put on a medical protective mask without valve or a medical protective mask with valve covered with a medical surgical mask

[b] Working clothes indicate that different professions have a unique clothing in different countries, for example, dentist scrub top/pants, white coats for doctors in clinic, surgical scrubs for operating surgeons, security uniforms for security guards, and cleaning uniforms for general cleaners

[c] Handpiece should be flushed for 30 s before and after each dental procedure

[d] Mouth rinses such as povidone-iodine are recommended, while 0.05–0.2% benzalkonium chloride, and 0.02% chlorhexidine digluconate and hydrogen peroxide are not recommended

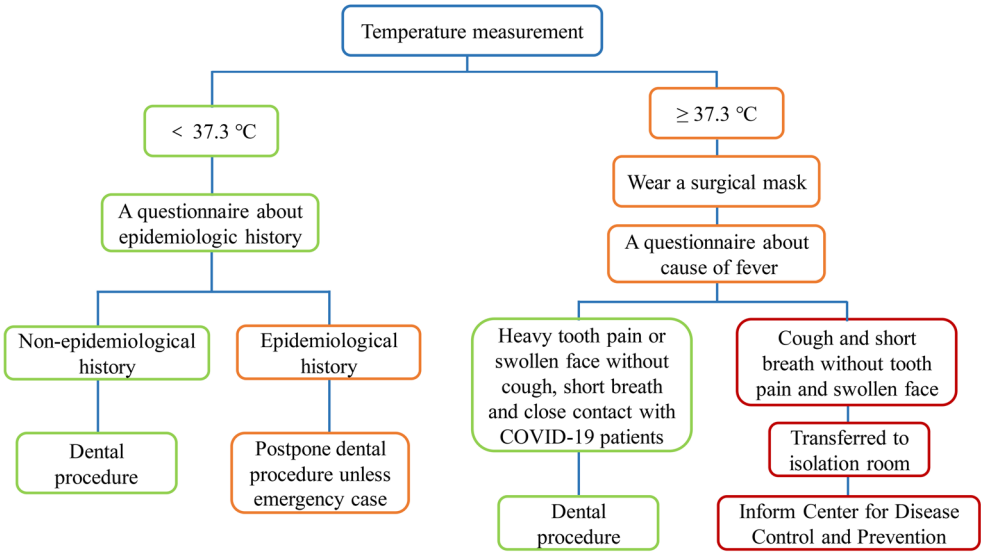

Fig. 1 Illustration of patient triage in the hospital. Epidemiological history includes (within the past 14 days) travel to/or resident in severe COVID-19 epidemic countries and territories; close contact with individuals coming from severe COVID-19 epidemic countries and territories; and close contact with patients with confirmed COVID-19 infection/suspected COVID-19 cases

treatment bills were analyzed and aerosol-generating procedures, including an open access to pulp chamber using high-speed handpiece devices, were investigated. Data from the same period were compared year-on-year (2020-on-2019).

SARS-CoV-2 detection and serological testing

To complete work resumption, hospital staff, including dentists, nurses, students, security guards, and cleaners, at the Affiliated Stomatology Hospital, Zhejiang University School of Medicine (Hangzhou, China) underwent mandatory testing, free of charge, for SARS-CoV-2 detection using nasopharyngeal swabs, real-time fluorescence RT-qPCR, and serological testing (IgG, IgM) during the period of April 28–29, 2020. The detection of SARS-CoV-2 using the RT-qPCR test kits and IgM/IgG antibody rapid tests using the colloidal gold method were performed by Dian Diagnostics Co., Hangzhou, China.

Results

A total of 49,007 patient visits (21,138 males and 27,869 females) were included in this study (Table 2). The number of patient visits per day is listed in Fig. 2. Some patients underwent aerosol-generating procedures. Adults aged 25–64 years constituted the largest proportion of patients during the lockdown and reopening periods. Near 50% of all patients complained of tooth pain due to pulpitis, periapical periodontitis, and periodontal abscess (Table 2). The number of the patient visits per day in the reopening period was significantly increased compared to that in the lockdown period (Fig. 2).

The distribution of patient visits during the lockdown and reopening periods in 2020 and during the corresponding periods in 2019 is listed in Table 3. The number of emergency visits was significantly increased to approximately 16- and 6.4-fold during the lockdown and reopening periods, respectively, compared with that during corresponding periods in 2019. The total number of patient visits decreased to 6% (lockdown) and 58% (reopening), respectively.

A total of 757 staff members underwent nasopharyngeal swab RT-qPCR testing and serological testing. The results showed that for none of the staff members RT-qPCR testing and serological testing (IgG, IgM) were positive. Another 17 hospital members, who were on maternity leave or sick leave, were not tested on April 28 and 29, 2020. However, they were tested before they gave birth or returned to work, and none was positive.

Discussions

The data obtained in this study revealed the significant decline in dental services during the COVID-19 epidemic in the Zhejiang province, China. The COVID-19 epidemic had a negative influence on people's dental care–seeking behavior. The female proportion of dental patients was dramatically increased from 47.2% during the lockdown period to 57.4% during the reopening period (Table 2). This might be attributed to the reduced demands of female dental patients, which might be explained by the fact that females showed more apprehension of contracting acute viral respiratory tract infections than males when undergoing dental procedures [20]. Adults at a working age (25 to 64 years) constituted the largest proportion of dental patients (Table 2), and comprise the largest proportion of the population in Zhejiang, China. Due to lack of regular dental service, emergency visits during the lockdown period in Hangzhou, China, were dramatically increased compared with the corresponding period in 2019 (Table 3).

Table 2 Demographic characteristics of patient visits admitted in the hospital during lockdown and reopening periods in 2020

	Patient visits in total (*n* (%))	Patient visits in lockdown period (*n* (%))	Patient visits in reopening period (*n* (%))
Gender			
Male	21,138 (43.1)	1353 (52.8)	19,785 (42.6)
Female	27,869 (56.9)	1208 (47.2)	26,661 (57.4)
Age			
0–14	10,569 (21.6)	448 (17.5)	10,121 (21.8)
15–24	7501 (15.3)	225 (8.8)	7276 (15.7)
25–64	28,438 (58.0)	1695 (66.2)	26,743 (57.6)
65+	2499 (5.1)	193 (7.5)	2306 (5.0)
Diagnosis			
Pulpitis	4595 (9.4)	647 (25.2)	3948 (8.5)
Trauma	230 (0.5)	44 (1.7)	186 (0.4)
Periapical periodontitis	5085 (10.4)	475 (18.5)	4610 (9.9)
Periodontal abscess	83 (0.2)	28 (1.1)	55 (0.1)
Others[a]	39,014 (79.6)	1367 (53.4)	37,647 (81.1)
Total	49,007 (100.0)	2561 (100.0)	46,446 (100.0)

Patient visits are presented in number (*n*) and percentage (%)

[a] Others include cellulitis, chronic periodontitis, oral mucosal diseases, tooth defect, impacted tooth, and patients need for orthodontic treatments

Pre-operative procedures

To reduce patients' gatherings in the dental hospital, patients were asked to make a dental appointment via the internet or by telephone in advance. Patient triage was performed by a questionnaire about epidemiological history and temperature measurement (Fig. 1). If patients had an increased body temperature or fever (body temperature ≥ 37.3°C), they were immediately given medical surgical masks. Patients were asked whether they had cough and were short of breath or had heavy tooth pain or a swollen oral maxillofacial region. If patients had a fever and/or cough and were short of breath without tooth pain and a swollen face, they were immediately transferred to an isolation room until they were picked up by healthcare staff from the Center for Disease Control and Prevention (CDC) as per the Chinese epidemiological regulation [21]. If patients had heavy tooth pain or a swollen face without any cough and shortness of breath, and were in close contact with COVID-19 patients, they were allowed undergoing a dental procedure [8]. This was also the case for patients with a normal body temperature and who were not in close contact with COVID-19 patients and did not travel to COVID-19 epidemic cities, countries, and territories. If patients experienced severe pain and a swollen face with a cough, which worsens a patients' general health, they were immediately transferred to an isolation room. Next, an emergent procedure, such as open access to a pulp chamber and incision of an abscess, should be carried out. Subsequently, patients waited for pick-up by CDC healthcare staff. COVID-19-suspected patients and healthcare workers were tested for SARS-CoV-2 and quarantined until a clean testing report was received. Otherwise, dental procedures were postponed. All

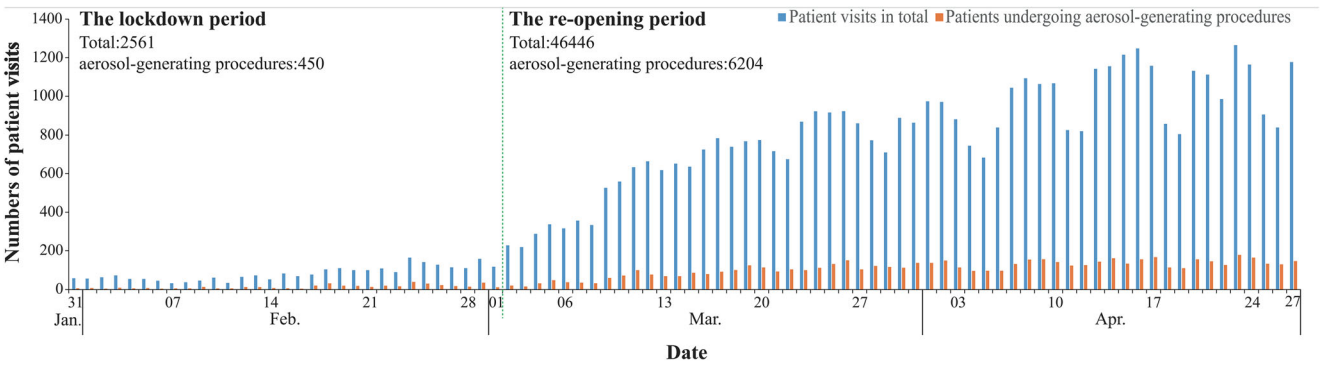

Fig. 2 Total number of patient visits and the number of patients who underwent aerosol-generating procedures in the hospital between January 31, 2020, and April 27, 2020

Table 3 The distribution of patient visits (*n* (%)) in lockdown and reopening periods in 2020 and in the corresponding periods in 2019

Timeframes	Lockdown period			Reopening period		
	January 7 to February 8, 2020	January 7 to February 7, 2019	Ratio (2020/2019)	February 9 to April 5, 2020	February 8 to April 5, 2019	Ratio (2020/2019)
Emergency visits	2561 (100.0)	160 (0.35)	16.01	2041 (4.39)	318 (0.40)	6.42
Total patient visits	2561 (100.0)	45,517 (100.0)	0.06	46,446 (100.0)	79,525 (100.0)	0.58

Timeframes were converted from the solar calendar (January 31 to March 1; March 2 to April 27, 2020) into Chinese lunar calendar (January 7 to February 8; February 9 to April 5, 2020) to obtain the same working days. The year 2020 was a leap year with one extra day (February 29, 2020). Therefore, February 9, 2020, in Chinese lunar calendar was correspondingly antedated to February 8, 2019, for identical working days

patients were instructed to correctly wear face masks and follow a cough etiquette and social distancing [22]. Companions were not allowed entering treatment room unless absolutely necessary [23].

Mouth rinse before dental procedures can reduce a great number of microbes and viral load in the oral cavity [24, 25]. Mouth rinses that efficiently inactivate coronaviruses are recommended, such as povidone-iodine [3, 26]. However, less effective mouth rinses, such as 0.05–0.2% benzalkonium chloride and 0.02% chlorhexidine digluconate, are not recommended [27]. Recently, the virucidal effectiveness of hydrogen peroxide mouth rinses is questionable; therefore, mouth rinses with hydrogen peroxide before dental procedure are no longer recommended [28]. A rubber dam was recommended to be applied and high-volume suction should be implemented whenever a high-speed handpiece device is used, for example, open access to a pulp chamber in case of acute pulpitis. Any aerosol-generating procedures were implemented in an isolated room, or at least in an interval of a dental chair, if an isolation room was not available.

Healthcare staff protective measures

Dentists and nurses are at high risk of SARS-CoV-2 transmission from their dental patients due to close contact, body fluids, droplets, and aerosol-generating procedures; therefore, standard precaution is of critical importance during dental services, including proper usage of personal protective equipment (PPE) and hand hygiene [29]. This is a routine prerequisite for reducing contact contagion. A suggestive rationalization use of PPE and a dental setting/device are summarized according to the risk in different situations (Table 1). Standard medical protective masks, for example, N95 masks or equivalent respirators, should be donned during aerosol-generating procedures [30]. Face shields should also be recommended as they could isolate the facial area from aerosols and spatters of body fluids [30]. In this situation, disposable shoe covers are also suggested to be put on. Dentists and nurses should pay high attention to the removal process of PPE and hand hygiene before leaving the treatment room. In addition, hospital administrators should focus on additional measures that prevent dentists and nurses from having to work in a condition that is detrimental to their health and well-being as well as to the safety and quality of the care they provide.

Although sensitivity of the RT-qPCR technique might depend on the timing of disease presentation, sampling location, and severity of illness [31], RT-qPCR remains the gold standard test because of the high specificity. The testing method is chemically stable without cross-reactivity with other coronaviruses, and excludes false-positive outcomes based on clinical samples, which pre-tested positive for other respiratory viruses [32]. Despite its high specificity, serological testing cannot exclude COVID-19 due to the limited sensitivity [31]. Therefore, it should only be used as an important test to assist in the diagnosis of COVID-19 [19]. None of the hospital staff was infected with SARS-CoV-2. This indicated that the prevention strategy successfully prevented SARS-CoV-2 infections among healthcare workers in the dental hospital. Although the study did not provide the exact data of asymptomatic patients who were treated during the lockdown and reopening periods, the proportion ratio of asymptomatic patients with COVID-19 in the dental hospital was around 0.3% (Appendix in the Supplementary Information). This is much lower than the prevalence of COVID-19, which was around 2.54% (1218 cases/47,966 close contact persons) in Zhejiang, China [33]. Thus, asymptomatic carriers with SARS-CoV-2 were estimated to be 49–73.5 during the study period (Appendix in the Supplementary Information). These findings further demonstrated the effectiveness and significance of the applied prevention strategy against the spread of COVID-19 in the dental hospital. The promising data of this prevention strategy could be used as a reference for other countries and territories where patients are suffering from COVID-19 pandemic.

Limitations in this study

It is not known whether there were asymptomatic carriers of SARS-CoV-2 among dental patients since not all patients were tested for SARS-CoV-2. The effectiveness and significance of the prevention strategy need to be further verified after treatment of dental patients who contracted SARS-CoV-2. Combining RNA detection with antibody testing significantly increased the diagnostic sensitivity of COVID-19 to 99.4% [34]. However, there is still a risk of small number of false-negative results because of the large number of staff members. Currently, there is no agreed definition of aerosol-generating procedures [35]. The aerosol-generating procedure documented in this study only involved high-speed handpiece devices and ultrasonic instruments. Other aerosols generated by air-water syringes, prophylaxis, etc. were not sufficiently discussed [35]. Thus, the current methodical approach fails to quantify all aerosol-generating procedures. The information of aerosol-generating procedures was obtained from the datasets of diagnosis and treatment bills, and was based on standard diagnosis and treatment bills. Therefore, the number of aerosol-generating procedures might be more than the numbers presented in Fig. 2. Not exacting data on the adherence to proper PPE use is a limitation of the present study.

Conclusions

The total number of patient visits was significantly reduced, whereas emergency visits were greatly increased during the COVID-19 pandemic. Healthcare staff in a dental facility should pay much attention not only to patient triage but also to proper use of PPE. The prevention strategy adopted in this study successfully prevented the SARS-CoV-2 spread among healthcare workers in a dental hospital.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00784-021-03886-9.

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Declarations

Ethics approval All patients included in this study signed written informed consent and agreed that their health-related data would be used for teaching and research purposes. All health-related data were anonymized. Use of these health-related data in the study was strictly abided by the International Ethical Guidelines of the Declaration of Helsinki (World Medical Association, 2008) [36] and National Ethics Censorship of Biomedical Research Involving Human Subject [37]. This study was approved by the Institutional Ethic Board of the Affiliated Stomatology Hospital, Zhejiang University School of Medicine (Hangzhou, China) (No. 2020-16).

Conflict of interest The authors declare no competing interests.

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