Is hydrogen peroxide an effective mouthwash for reducing the viral load of SARS-CoV-2 in dental clinics?

Emma Burgos-Ramos a, Itziar R. Urbieta b, Diana Rodríguez c, *

**Biochemistry Area, Faculty of Environmental Sciences and Biochemistry, University of Castilla-La Mancha, Avenida Carlos III s/n, 45071 Toledo, Spain**

**Department of Environmental Sciences, Faculty of Environmental Sciences and Biochemistry, University of Castilla-La Mancha, Avenida Carlos III s/n, 45071 Toledo, Spain**

**Department of Physical Chemistry, Faculty of Environmental Sciences and Biochemistry, University of Castilla-La Mancha, Avenida Carlos III s/n, 45071 Toledo, Spain**

Received 3 September 2021; revised 24 December 2021; accepted 24 January 2022

Available online 29 January 2022

**KEYWORDS**

Airborne SARS-CoV-2; COVID-19 free room; Hydrogen peroxide mouthwash; Oral health; Portable air cleaner; HEPA filter

**Abstract**

**Background:** Previous studies have demonstrated that SARS-CoV-2 is mainly transmitted by inhalation of aerosols and can remain viable in the air for hours. Viruses can spread in dental settings and put professionals and patients at high risk of infection due to proximity and aerosol-generating procedures, and poor air ventilation.

**Objectives:** The aim of this study was to investigate the effects of a 1% hydrogen peroxide (H$_2$O$_2$) mouth rinse on reducing the intraoral SARS-CoV-2 load.

**Methods:** Portable air cleaners with HEPA filters exposed for 3 months were analysed to test for virus presence in a waiting room (where patients wore a face mask but did not undergo mouth rinsing) and three treatment rooms (where patients wore no mask but carried out mouth rinsing). As CO$_2$ is co-exhaled with aerosols containing SARS-CoV-2 by COVID-19 infected people, we also measured CO$_2$ as a proxy of infection risk indoors. Specific primer and probe RT-PCR were applied to detect viral genomes of the SARS-CoV-2 virus in the filters. Specifically, we amplified the nucleocapsid gene (Nuclv) of SARS-CoV-2.

**REFERENCES**

https://doi.org/10.1016/j.sdentj.2022.01.005

1013-9052 © 2022 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University.

This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
1. Introduction

Coronavirus disease 2019 (COVID-19), caused by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), has caused a large number of infections worldwide. The transmission of SARS-CoV-2, from asymptomatic, presymptomatic, and symptomatic carriers, occurs mainly via respiratory droplets, aerosols, and to a lesser extent, fomites (Guo et al., 2020; Mondelli et al., 2021). The virus can stay suspended and viable for hours in aerosols depending on factors like heat and humidity (van Doremalen et al., 2020), and it can stay suspended and viable for hours in aerosols depending on factors like heat and humidity (van Doremalen et al., 2020), and it can be transmitted up to distances of 4 m (Guo et al., 2020).

Dentistry is considered a high-risk profession during a transmissible infectious disease pandemic due to proximity to the patient’s respiratory tract openings during dental exams and treatments, despite the use of basic personal protective equipment (Harrel and Molinari, 2004). Since the emergence of the COVID-19, appropriate guidance for dental professionals to protect both themselves and their patients against SARS-CoV-2 has become a critical topic. However, the evidence on this issue is still controversial (Shamsoddin et al., 2021). The World Health Organization (WHO) has considered “airborne precautions” for healthcare workers, particularly in dental clinics where, due to the nature of dental procedures (Coulthard, 2020), saliva may become aerosolized and thus contribute to the spread of the virus from the oral cavity (Askarian et al., 2005; Benzian et al., 2021). Therefore, preventive measures that minimize the transmission of the virus in this setting are essential.

Mouthwashes are widely used before oral surgery due to their ability to reduce the number of microorganisms in the oral cavity (Dominiak et al., 2020; Kosutic et al., 2009) and colony forming units in dental aerosols (Marui et al., 2019). Moreover, based on the existing evidence, the use of mouthwashes in COVID-19 patients admitted to ICU (intensive care units) is currently suggested before performing daily routine procedures with a potential risk of generating aerosols, and/or droplet emission (e.g., Tovani-Palone and Shamsoddin, 2021). Recent studies have found that rinsing solutions successfully inactivate infectious SARS-CoV-2 particles (e.g., Koch-Heier et al., 2021), and reduce salivary viral load (Meister et al., 2020; Moosavi et al., 2020). In this context, the CDC (Centers for Disease Control and Prevention) have recommended the use of mouthwashes before oral procedures (CDC, 2020; Tovani-Palone et al., 2021). A variety of oral antiseptic rinses have been suggested in recent literature for preprocedural use to reduce viral transmission. Oral rinses ranging from chlorhexidine gluconate, ethanol, essential oils, povidone-iodine (PVP-I), hydrogen peroxide (H2O2) chlorinated water, hypertonic saline, bioflavonoids, cyclodextrins, cetylpyridinium chloride have been recommended (Vergara-Buenaventura and Castro-Ruiz, 2020).

Hydrogen peroxide oral rinse is a popular rinse anecdotally used by dentists due to its long history of use in teeth whitening procedures. Some of the advantages of H2O2 include easy accessibility, low cost, and long track record in dentistry. However, its disadvantages include its potential for toxicity. In this study we assessed the potential efficacy of rinsing with H2O2 as a virucidal mouthwash in reducing the risk of coronavirus transmission. We used a relatively low concentration of 1% (lower concentration than indicated in previous studies 1.5–3%) (e.g., Bidra et al., 2020; Tovani-Palone and Shamsoddin, 2021), for 1 min to reduce its potential toxicity. This could be considered as the main preventive option to control the viral load in the saliva and the aerosol during any dental procedure. As an additional preventive measure, the CDC have considered the use of particle-size range portable air cleaners (PACs) with high-efficiency particulate air (HEPA) filters while the patient is undergoing, and immediately following, an aerosol-generating procedure. SARS-CoV-2 has a diameter of 0.06–0.14 μm, with characteristic spikes ranging from 0.009 to 0.012 μm (Wiersinga et al., 2020). The spreading of coronavirus through aerosols, in the size range up to 5 μm diameter, is a significant transmission pathway of COVID-19 (Cai et al., 2020). These devices can be captured by PACs with HEPA filters efficiently (Hammond et al., 2021; Rodriguez et al., 2021). These devices typically consist of a fan and a HEPA filter where the air purifier pulls air in, passes it through the filter to remove particles, and then dumps clean air back into the room, thus removing potentially contaminated air. Therefore, PACs with HEPA filters could reduce the spread of SARS-CoV-2 and improve the indoor air quality in rooms with low ventilation rates (Ren et al., 2021).

The purpose of this study was to assess the potential efficacy of 1 min of rinsing with 1% H2O2 as a virucidal mouthwash in reducing the risk of coronavirus transmission. We compared the viral loads captured by portable air cleaners (PAC) with HEPA filters exposed for 3 months in different rooms of a dental clinic during one of the COVID-19 pandemic peaks in Spain.

2. Methodology

2.1. Sampling

The study was carried out in the dental clinic “TD” in the city of Toledo (located 60 km south of Madrid), one of the Spanish cities with a high rate of infection, during the third wave COVID-19 pandemic peak (https://cenecovid.isciii.es/).
(Fig. 1). PACs with HEPA filters exposed for 3 months (from January to March 2021) were analysed to test for virus presence in a waiting room (where patients wore a face mask but did not undergo mouth rinsing), and three treatment rooms (where patients wore no mask but carried out 1 min mouth rinsing with 1% H\textsubscript{2}O\textsubscript{2}).

Patients attended the clinic with prior appointment and one by one after a temperature check. No companions were allowed due to the sanitary restrictions, except on a few occasions. A mask was mandatory, and hands were cleaned with an alcohol-based hand rub before going into the waiting room. Patients would wait for c.a. 5–10 min in the waiting room and then moved to one of the three treatment rooms in the clinic, where they rinsed their mouth for 1 min with 1% H\textsubscript{2}O\textsubscript{2} mouthwash and remained without their mask for the whole dental treatment.

PACs with HEPA filters were placed in the centre of the treatment rooms, ensuring unobstructed airflow. However, the PAC in the waiting room was placed behind the seats where patients sat while waiting for their appointment. The PAC models used for this study were Blueair 403 (placed in the waiting room, measuring 22.75 m\textsuperscript{2}) and Blueair 203 (placed in the treatment rooms, each measuring 9.80 m\textsuperscript{2}). The specifications of both models were the same in terms of the pore size of the filters. They only differed in the clean air delivery rate (CADR), with five air changes per hour for up to 34 m\textsuperscript{2} surface area (for the 403 model) and up to 22 m\textsuperscript{2} surface area (for the 203 model). Model 403 had four speed levels (airflow 408 m\textsuperscript{3}/h) and model 203 had three speed levels (airflow 290 m\textsuperscript{3}/h). Both models capture 99.97% of airborne particles down to 0.1 \textmu m in size.

The clinic used an air conditioner as a ventilation system, and large fixed frameless windows were the only source of natural light, so there was no natural ventilation. Carbon dioxide (CO\textsubscript{2}) concentration is an important indicator of ventilation in indoor environments. Moreover, CO\textsubscript{2} is co-exhaled with aerosols containing SARS-CoV-2 by COVID-19 infected people and can be used as a proxy of SARS-CoV-2 concentrations indoors (Peng and Jimenez, 2021). For this reason, we also measured CO\textsubscript{2} with a portable infrared sensor Testo 315-3 in each room during the 3 months of the study. The sensor was calibrated within the year preceding the study.

2.2. Filter analysis

2.2.1. HEPA filter samples

We analysed HEPA filter samples from four rooms of the dental clinic (waiting room and three treatment rooms). The filters were randomly cut into pieces of 3 × 3 cm, using sterilized scissors, and placed in vials containing 1.5 ml of diethylpyrocarbonate (DEPC)-treated water with 0.5% bovine serum albumin (BSA) in order to inhibit the ribonucleases and protect the viral structures present on the filters, and stored at 4°C until assayed. Six pieces of each filter were analysed.

2.2.2. RNA extraction, reverse transcription (RT), and real-time PCR

Prior to RNA extraction, the filter samples were incubated while being shaken for 45 min at high speed, after which the filter pieces were removed and 300 \textmu l of QIAzol lysis reagent was added. Total RNA was extracted according to the QIAzol manual (Qiagen) and was quantified using the NanoDrop 2000 (Take3, BioTek). Complementary DNA (cDNA) was synthesised from 1 \textmu l of DNase-treated RNA. Real-time PCR was performed in duplicate, in a total volume of 20 \textmu l, containing 5 \textmu l of the RT reaction, in an ABI Prism 7500 Fast Sequence Detection System (Applied Biosystem, Foster City, CA) as previously described (Burgos-Ramos et al., 2012). SYBRGreen gene expression assays were used to detect SARS-CoV-2 nucleocapsid (Nuclv) as a marker of viral presence, and 18S ribosomal as an endogenous control of the method. The forward and

![Fig. 1 Epidemic curve of the COVID-19 pandemic in Toledo. The arrow indicates the start of the third outbreak (Modified from: https://cnecovid.isciii.es/covid19/#provincias).](https://cnecovid.isciii.es/covid19/#provincias)
reverse primers were as follows: 5'-CAATGCTGCAATCGTGCTAC-3' and 5'-GTTGCGACTACGTGATGAGG-3' for Nuclv, and 5'-TCTGCCCCATCAACTTTCGATGG-3' and 5'-TAATTTGCGCGCCTGCTG-3' for 18S. According to the manufacturer's guidelines, the Cycle threshold (Ct) method was used for relative quantification, considering a sample positive for SARS-CoV-2 when the Ct value was less than or equal to 41 (Rodrıñguez et al., 2021).

2.2.3. Statistical analysis
Data are expressed as means ± SEM (standard error of the mean) of six pieces of each filter analysed in duplicate. Statistical analysis was performed using one-way ANOVA (GraphPad Prism 5.03 software, GraphPad Software, Inc., San Diego, CA). Statistical significance was set at p < 0.05.

3. Results
SARS-CoV-2 was detected in the filter of the waiting room (mean Ct value = 36.41 ± 1.51), although the use of a mask was mandatory (Fig. 2 Panel A). This could be due to the type of mask used or its incorrect use, i.e., because masks were not well-fitted (leaving gaps), or because they were used longer than recommended. However, we did not detect virus in the filters from the treatment rooms. We ruled out the possibility that this absence was due to a technical failure, as 18S expression was homogeneous in all analysed filters, as demonstrated in the ANOVA (p value = 0.325) (Fig. 2 Panel B). The mean Ct value for 18S expression was 16.18 ± 0.73 in the waiting room; 15.84 ± 1.09 in treatment room 1; 17.71 ± 1.01 in treatment room 2 and 17.87 ± 0.84 in treatment room 3. Moreover, some patients notified the clinic of a positive PCR test after dental care. In addition, asymptomatic patients may have attended the clinic.

4. Discussion
Our results demonstrated that the dental treatment room could be considered a COVID-free room, because patients rinsed their mouths with 1% H2O2 solution for 1 min immediately after removing their mask, deleting viral particles from their mouth. This could explain the absence of viral load in filters from these rooms. The use of mouthwashes has been found to be effective at reducing the microbial count in the oral cavity (Marui et al., 2019). Recent evidence has confirmed that rinsing the mouth with 0.5% povidone-iodine (PVP-I) (iodine with water-soluble polymer polyvinylpyrrolidone) for 30 s can reduce SARS-CoV-2 virus infectivity (Chopra et al., 2021), as can chlorhexidine 0.2% and 1% PVP-I oral solutions (Elzein et al., 2021). However, there are conflicting reports on the in vivo efficacy of H2O2 against SARS-CoV-2 (Ather et al., 2021; Ortega et al., 2020). H2O2 contains one more atom of oxygen than water (H2O) that is eventually used in oxidation reactions. No adverse effects were reported from the use of a mouth rinse containing 1% H2O2 when it was not used often (Gusberti et al., 1988). H2O2 degrades into oxygen and H2O when it is in contact with an enzyme (catalase) present in almost all living beings, including microorganisms within the oral microbiota, and this oxidative process would be effective against SARS-CoV-2 because the virus is sensitive to oxidation (Peng et al., 2020; Rowen and Robins, 2020).

In a recent study that modeled factors associated with the spread of respiratory infectious disease in dental offices, CO2 levels were found to play the most important role in the risk of disease transmission (Huang et al., 2021). CO2 levels at 774 ppm were considered low risk, but those at or above 1,135 ppm may increase the risk of disease transmission in dental offices (Zemouri et al., 2020). In our case, the average CO2 concentration in the waiting room was 890 ppm, and it was between 907 and 860 ppm in the treatment rooms. These
values indicate that transmission of the virus inside the clinic is plausible due to the poor ventilation.

5. Conclusions

Until mass vaccination is successfully implemented globally, dental practices are not totally secure for either staff or patients. Dentists should install preventive strategies to avoid the spread of COVID-19 infection. This study highlights the importance of \( \text{H}_2\text{O}_2 \) mouth wash in controlling airborne spread of SARS-CoV-2 in an indoor environment with poor ventilation and without safe social distancing.

The use of \( \text{H}_2\text{O}_2 \) solution (1%) for 1 min for mouth rinsing drastically reduced the possibility of coronavirus spread during aerosol-generating dental procedures. Our results suggest that this procedure could be one of the main strategies to limit SARS-CoV-2 transmission in dental clinics. The use of a mouthwash prior to a dental procedure is recommended, as soon as a patient arrives at the clinic, to prevent the spread of SARS-CoV-2 to staff and other patients.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Authors thank Dr. P. T. for allowing the study in his dental clinic.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Statement

D.R (diana.rodriguez@uclm.es) and I.R.U (itziar.rodriguez@uclm.es) created the project, measured the CO\(_2\) concentration, and collected the HEPA filters. E.B-R. (emma.burgos@uclm.es) did the analyses. All authors drafted the manuscript and contributed to the discussion of the results.

Ethical Statement

This article requires no human or animal in research.

References

Askarian, M., Mirraei, K., Honarvar, B., Ettminan, M., Araujo, M.W.B., 2005. Knowledge, attitude and practice towards droplet and airborne isolation precautions among dental health care professionals in Shiraz, Iran. J. Public Health Dentistry 65 (1), 43–47. https://doi.org/10.1111/j.1752-7325.2005.tb02785.x.

Ather, A., Parolia, A., Ruparel, N., 2021. Efficacy of Mouth Rinses against SARS-CoV-2: A Scoping Review. Front. Dent. Med. 2, 648547. https://doi.org/10.3389/fdmed.2021.648547.

Benzian, H., Beltrán-Aguilar, E., Mathur, M.R., Niederman, R., 2021. Pandemic considerations on essential oral health care. J. Dent. Res. 100 (3), 221–225. https://doi.org/10.1177/0022034520979830.

Bidra, A.S., Pelletier, J.S., Westover, J.B., Frank, S., Brown, S.M., Tessaema, B., 2020. Comparison of in vitro inactivation of SARS CoV-2 with hydrogen peroxide and povidone-iodine oral antisepic rinses. J. Prosthodontics 29 (7), 599–603. https://doi.org/10.1111/jopr.13220.

Burgos-Ramos, E., Canelles, S., Perianes-Cachero, A., Arilla-Ferreiro, E., Argente, J., Barrios, V., 2012. Adipose tissue promotes a serum cytokine profile related to lower insulin sensitivity after chronic central leptin infusion. PLoS ONE 7 (10), e46893. https://doi.org/10.1371/journal.pone.0046893.

Cai, J., Sun, W., Huang, J., Gamber, M., Wu, J., He, G., 2020. Indirect Virus Transmission in Cluster of COVID-19 Cases, Wenzhou, China, 2020. Emerg. Infect. Dis. 26 (6), 1343–1345. https://doi.org/10.3201/eid2606.200412.

CDC, 2020. Centers for Disease Control and Prevention. Interim infection prevention and control guidance for dental settings during the COVID-19 response. Available from URL: https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html (Accessed July 26, 2021).

Chopra, A., Sivaraman, K., Radhakrishnan, R., Balakrishnan, D., Narayana, A., 2021. Can povidone iodine gargle/mouthrinse inactivate SARS-CoV-2 and decrease the risk of nosocomial and community transmission during the COVID-19 pandemic? An evidence-based update. Jpn. Dent. Sci. Rev. 57, 39–45. https://doi.org/10.1016/j.jdsr.2021.03.001.

Coulthard, P., 2020. The oral surgery response to coronavirus disease (COVID-19). Keep calm and carry on? Oral Surg. 13 (2), 95–97. https://doi.org/10.1111/ors.12489.

Dominik, M., Shuleva, S., Silvestros, S., Alcoforado, G., 2020. A prospective observational study on perioperative use of antibacterial agents in implant surgery. Adv. Clin. Exp. Med. 29 (3), 355–363. https://doi.org/10.17219/acem/115087.

Elzein, R., Abdel-Sater, F., Fakhreddine, S., Abi Hanna, P., Feghali, R., Hamad, H., Ayoub, F., 2021. In vivo evaluation of the virucidal efficacy of Chlorhexidine and Povidone-iodine mouthwashes against salivary SARS-CoV-2. A randomized-controlled clinical trial. J. Evid. Based Dent. 21 (3), 101584. https://doi.org/10.1016/j.jebdp.2021.101584.

Guo, Z., Wang, Z., Zhang, S., Li, X., Li, L., Li, C., Cui, Y., Fu, R., Dong, Y., Chi, X., Zhang, M., Liu, K., Cao, C., Liu, B., Zhang, K., Gao, Y., Lu, B., Chen, W., 2020. Aerosol and Surface Distribution of Severe Acute Respiratory Syndrome Coronavirus 2 in Hospital Wards, Wuhan, China, 2020. Emerg. Infect. Dis. 26 (7), 1583–1591. https://doi.org/10.3201/eid2607.200885.

Gusberti, F.A., Sampathkumar, R., Siegrist, B.E., Lang, N.P., 1988. Microbiological and clinical effects of Chlorhexidine diguconate and hydrogen peroxide mouthrinses on developing plaque and gingivitis. J. Clin. Periodontol. 15 (1), 60–67. https://doi.org/10.1111/j.1600-051x.1988.tb01556.x.

Hammond, A., Khalid, T., Thornton, H.V., Woodall, C.A., Hay, A. D., 2021. Should homes and workplaces purchase portable air filters to reduce the transmission of SARS-CoV-2 and other respiratory infections? A systematic review. PLoS One 16 (4). https://doi.org/10.1371/journal.pone.0251049.

Harrel, S.K., Molinari, J., 2004. Aerosols and splatter in dentistry: a brief review of the literature and infection control implications. J. Am. Dent. Assoc. 135 (4), 429–437. https://doi.org/10.4219/jada.archive.2004.0207.

Huang, Q., Marzouk, T., Cirliğeanu, R., Malmstrom, H., Eliav, E., Rom, Y.-F., 2021. Ventilation rate assessment by carbon dioxide measurements in dental treatment rooms. J. Dental Res. 100 (8), 810–816. https://doi.org/10.1177/00220345211014441.

Koch-Heier, J., Hoffmann, H., Schindler, M., Lussi, A., Planz, O., 2021. Inactivation of SARS-CoV-2 through Treatment with the Mouth Rinsing Solutions ViruProX® and BacterX® Pro. Microoro-
Kosutic, D., Uglesic, V., Perzic, D., Solman, L., Lupi-Ferandin, S., Knezevic, V., Sokler, K., Knezevic, K., 2009. Preoperative antiseptics in clean/contaminated maxillofacial and oral surgery: prospective randomized study. Int. J. Oral Maxillofac. Surg. 38 (2), 160–165. https://doi.org/10.1016/j.ijom.2008.11.023.

Marui, V.C., Souto, M.L., Rovai, E.S., Romito, G.A., Chambrone, L., Pannuti, C.M., 2019. Efficacy of preprocedural mouthrinses in the reduction of microorganisms in aerosol: a systematic review. J. Am. Dent. Assoc. 150 (12), 1015–1026. https://doi.org/10.1016/j.adaj.2019.06.024.

Meister, T.L., Brüggemann, Y., Todt, D., Conzelmann, C., Müller, J. A., GroB, R., Münch, J., Krawczyk, A., Steinmann, J., Steinmann, J., Pfaender, S., Steinmann, E., 2020. Virucidal efficacy of different oral rinses against Severe Acute Respiratory Syndrome Coronavirus 2. J. Infect. Dis. 222 (8), 1289–1292. https://doi.org/10.1093/infectdis/jiaa471.

Mondelli, M.U., Colaneri, M., Seminari, E.M., Baldanti, F., Bruni, R., 2021. Low risk of SARS-CoV-2 transmission by fomites in real-life conditions. Lancet Infect. Dis. 21 (5), E112. https://doi.org/10.1016/S1473-3099(20)30878-2.

Moosavi, M.S., Aminshakib, P., Ansari, M., 2020. Antiviral mouthwashes: possible benefit for COVID-19 with evidence-based approach. J. Oral Microbiol. 12 (1), 1794363. https://doi.org/10.1080/20002297.2020.1794363.

Ortega, K.L, Rech, B.O., El Haje, G.L.C, Gallo, C.B., Perez -Sayans, M., Braz-Silv, P.H., 2020. Do hydrogen peroxide mouthwashes have a virucidal effect? A systematic review. J. Hosp. Infect. 106 (4), 657-662. https://doi.org/10.1016/j.jhin.2020.10.003.

Peng, X., Xu, X., Li, Y., Cheng, L., Zhou, X., Ren, B., 2020. Transmission routes of 2019-nCoV and controls in dental practice. Int. J. Oral Sci. 12 (1), 9. https://doi.org/10.1038/s41368-020-0075-9.

Peng, Z., Jimenez, J.L., 2021. Exhaled CO2 as COVID-19 infection risk proxy for different indoor environments and activities. Environ. Sci. Technol. Lett. 8 (5), 392–397. https://doi.org/10.1021/acs.estlett.1c00183.

Ren, Y.F., Huang, Q., Marzouk, T., Richard, R., Pembroke, K., Martone, P., Venner, T., Malmstrom, H., Eliav, E., 2021. Effects of mechanical ventilation and portable air cleaner on aerosol removal from dental treatment rooms. J. Dent. 105, 103576. https://doi.org/10.1016/j.jdent.2020.103576.

Rodriguez, M., Palop, M.L., Seseña, S., Rodríguez, A., 2021. Are the Portable Air Cleaners (PAC) really effective to terminate airborne SARS-CoV-2? Sci. Tot. Environ. 785, 147300. https://doi.org/10.1016/scitotenv.2021.147300.

Rowen, R.J., Robins, H., 2020. A Plausible, “Penny Costing Effective Treatment for Corona Virus - Ozone Therapy. J. Infect. Dis. Epidemiol. 6, 113. https://doi.org/10.23937/2474-3658/1510113.

Shamsoddin, E., DeTora, L.M., Tovani-Palone, M.R., Bierer, B.E., 2021. Dental care in times of the COVID-19 pandemic: a review. Med. Sci. 9, 13. https://doi.org/10.3390/medsci9010013.

Tovani-Palone, M.R., Shamsoddin, E., 2021. Use of mouthwashes in the management of COVID-19 patients in intensive care units: recommendations and current evidence. Einstein (São Paulo) 19, eCE6419. https://doi.org/10.31744/einstein_journal/2021CE6419.

Tovani-Palone, M.R., Shamsoddin, E., Franchi, T., 2021. Recommendations for safe paediatric dental practices during the COVID-19 pandemic: an update. Eur. J. Paediatr. Dent. 22.

van Doremalen, N., Bushmaker, T., Morris, D.H., Holbrook, M.G., Gamble, A., Williamson, B.N., Tamin, A., Harcourt, J.L., Thornburg, N.J., Gerber, S.I., Lloyd-Smith, J.O., de Wit, E., Munster, V. J., 2020. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N. Engl. J. Med. 382 (16), 1564–1567. https://doi.org/10.1056/NEJMc2004973.

Vergara-Buenaventura, A., Castro-Ruiz, C., 2020. Use of mouthwashes against COVID-19 in dentistry. Br. J. Oral. Maxillofac. Surg. 58 (8), 924–927. https://doi.org/10.1016/bjoms.2020.08.016.

Wiersinga, W.J., Rhodes, A., Cheng, A.C., Peacock, S.J., Prescott, H. C., 2020. Pathophysiology, transmission, diagnosis, and treatment of Coronavirus Disease 2019 (COVID-19). JAMA.324 (8), 782-793. https://doi.org/10.1001/jama.2020.12839.

Zemouri, C., Awad, S.F., Volgenant, C.M.C., Crielaard, W., Laheij, A.M.G.A., de Soet, J.J., 2020. Modeling of the Transmission of Coronavirus, Measles Virus, Influenza Virus, Mycobacterium tuberculosis, and Legionella pneumophila in Dental Clinics. J. Dent. Res. 99 (10), 1192–1198. https://doi.org/10.1177/0020354520940288.