**COVID-19 pandemic: Multilevel dental technical guidelines based on new scientific evidence**

**Pandemia de COVID-19: diretrizes técnicas odontológicas multiníveis baseadas em novas evidências científicas**

**Sérgio Araújo Andrade1,2,3\*,** **Raissa Emanuelle Lima3,** **Fernando de Pilla Varotti2,** **Omar Abdelwahab4, Bashir Abdulgader Lwaleed4**

1 São Carlos Institute of Physics, University of São Paulo, São Carlos, SP, Brazil

2 Research Center on Biological Chemistry (NQBio), Federal University of São João del-Rei (UFSJ), Divinópolis, MG, Brazil

3 School of Dentistry, University of Itaúna, Itaúna, Brazil

4 School of Health Sciences, University of Southampton, South Academic and Pathology Block (MP 11), Southampton General Hospital, Tremona Road, Southampton SO16 6YD, United Kingdom

**\*Corresponding author:** Sérgio Araújo Andrade

Núcleo de Pesquisa em Química Biológica

Avenida Sebastião Gonçalves Coelho, 400 – Chanadour Zip code: 35501-296 – Divinópolis, MG, Brazil Phone: (55 37) 3221-4657

 **E-mail:** saandrade@ufsj.edu.br

**ABSTRACT**

The COVID-19 pandemic imposed restrictive measures on Dentistry in different regions of the world, ranging from stoppage of care to only permission for urgent and emergency dental services. Thus, new biosafety guidelines for resuming activities, whether in single dental offices, large clinics or dental education activities, are urgently required. In this sense, herein, guidelines that incorporate common points of the main protocols found in the literature for the resumption of dental activities at their different levels, whether in the scope of care or education, are presented. Furthermore, we present the incorporation of measures that allow an increase in the level of biosafety, such as the control of the dental team, the inclusion in the anamnesis of conjunctivitis as a possible alert for COVID-19 and, the use of the pulse oximeter to assess the risk of silent hypoxemia, which may indicate a complication of COVID-19. In addition, new perspectives for directing research and innovation for biosafety in Dentistry are discussed.

**KEYWORDS:** Coronavirus Infections; COVID-19; SARS-CoV-2; Guideline; Dentistry, Biosafety; Medical Teletriage; Personal Protective Equipment;

**INTRODUCTION**

Undoubtedly, March 11, 2020 will be remembered for generations to come, when the World Health Organization (WHO) declared that COVID-19 is a pandemic.(1) In this context, governments around the world put strict measures to contain the spread of the outbreak, such as total lockdown.(2) Thus, there were countries or regions that have completely closed dental offices except for urgent and emergency care.(3–5) Thereupon, due to the need to reopen dental services, guidelines were postulated by regulatory agencies, class entities or suggested in the scientific literature, considering specific nuances of dental care and its risks in the context generated by SARS-CoV-2.(5–10) However, these protocols for urgent and emergency care or the resumption of activities in Dentistry should only be considered as a quick response and not as a broad and definitive solution.(4,11) Thus, such protocols must be constantly improved in order to not only provide solutions for a single viral type, but also to make the profession predictably safe. Herein, we present the principal converging regulations for resuming dental care, discussing the main impacts of these protocols, outlining perspectives for future research related to these biosafety measures imposed by COVID-19.

**Impacts of COVID-19 on Dentistry: a comprehensive perspective**

When proposing measures that impact or interrupt dental services, the healthcare regulatory agencies or class entities, need to consider oral health as an integral part of general health, with major impacts on the public well-being and quality of life. In this sense, dental caries and periodontal diseases have a progressive character, being among the most prevalent diseases with high potential for morbidity related to pain, infection and loss of function, which can lead to loss of teeth with its adverse psychosocial impacts. (7,12,13) In contrast, oral cancer has a high morbidity and mortality rates, affecting 500,550 people with 177,384 deaths in 2018 and its prognosis is severely affected by the delay in diagnosis.(12–14) Thus, it must be considered that measures that propose the suspension of Dentistry activities contribute to a greater probability that oral diseases will evolve, causing events with a greater risk of emergency or urgency, resulting in higher complexity and treatment costs.(7) Furthermore, the diagnosis of oral cancer is dependent on physical examination, which, is impossible to be performed by teletriage and teledentistry.(6,9) Therefore, the early diagnosis of oral cancer must be highly prioritised to prevent the disease from progressing causing serious and irreversible damage to the patient.(11,14–16)

It is noteworthy that dental workers are among the highest risk groups regarding the exposure to SARS-CoV-2, both for acting in close contact with the patient's upper airways and the possibility of contamination by aerosol and droplets generated during procedures, contaminated specimens or fomites.(3,5,6,8,9,11,17–19) In this context, guidelines from the Centers for Disease Control and Prevention (CDC), American Dental Association (ADA), United Kingdom National Health Service (NHS) and Occupational Safety and Health Administration (OSHA), have become the main references guiding practice of dental care during the pandemic.(6,7,11)

Thus, guidelines for resuming appointments or maintaining urgent and emergency dental services have been categorized into: 1) engineering control measures, 2) patient management, 3) face-to-face care protocols and 4) instructions for continuing dental education. (19) However, it should be emphasised that it is up to the local health authorities to define and adjust the scope of the measures to be followed to resume dental services based on the epidemiological and socio-economic complexity of each region.(11)

**Perspectives and preliminary guidelines regarding safeguard of dental staff and engineering control**

 The Table 1 summarises the main recommendations before face-to-face care in both the official guidelines and in scientific literature about COVID-19. (3,4,6–9,11,19)

**Table 1 - Recommendations prior to face-to-face appointment**

|  |  |
| --- | --- |
| **ADVICES** | **DESCRIPTION** |
| **Dental staff controls** | Dental workers with comorbidities (hypertension, diabetes, cardiorespiratory and/or cerebrovascular diseases, and cancer) and/or elderly should be removed from the frontline of clinical care, undertaking only administrative activities or teletriage.(4,8) |
| Dental workers with suspected or confirmed case of COVID-19 should be removed from the clinical frontline and kept under medical care.(3,6) |
| Asymptomatic dental workers should be monitored and tested for COVID-19.(3,6,11) |
| **Engineering controls** | Installation of physical barriers that maintain a minimum distance of 2 meters between people, whether they are patients and/or professionals.(6,8,11)  |
| Adequate ventilation with air flow directed from clean to less clean.(3,6,8) |
| Allow 20 to 30 minutes between consultations in order to ensure sufficient time for cleaning, disinfection, sterilisation and renewal of ambient air. In the waiting room, social distancing should be observed and strictly adhered to, magazines should be removed, as well as ornaments and toys and, if possible, avoid the presence of escorts. Intelligent scheduling for the patient to arrive at the dental office and be cared for "just in time” .(4,6–9,11,19) |
| Preferably, use an individualised dental office. In the case of dental clinics with a large number of chairs, a spacing between chairs of at least 2 meters should be promoted, which must be positioned parallel to the air flow, with physical barriers between chairs. If available, consider the use of a portable high-efficiency particulate air filtration unit (HEPA) in all types of dental offices.(6) |
| Use of plastic film in handle-able locations (e.g. door handles, equipment hand-pieces, handles of reflectors and keyboards).(7,19) |
| Avoid the use of a spittoon, prioritising, if possible, the use of high volume suction to minimise aerosol.(3,6,7,11,19) |

In the context of the proposed measures in Table 1, the dental worker carries a major and indispensable responsibility to safeguard themselves, individuals and the community. Dental workers are highly susceptible to occupational diseases and, especially the elderly and / or those with comorbidities, should be placed among high-risk groups to develop serious complications or mortality due to COVID-19.(4,20–24) Thus, public policies are urgently needed to sufficiently address the need of high risk professionals who may need to take a break from their jobs to avoid possible serious illnesses as a result of COVID -19 pandemic.

Furthermore, COVID-19 pandemic provided the opportunity for individuals to think and innovate in order to improve biosafety in Dentistry, including architectural aspects, patient flow, ventilation and aerosol minimisation, either by controlling its dispersion or using new dental techniques that would not allow the production of the aerosol.

**Perspectives and guidelines for a face-to-face dental care flow**

The table 2 shows the steps and the main characteristics related to the new flow required for resuming dental services during COVID-19. (3,5–9,11,19,25–32)

**Table 2: Steps and the main characteristics related to the new flow required for resuming dental services during COVID-19.**

| **STAGE** | **MEASURES APPLIED** |
| --- | --- |
| **Telephone or video conference triage** | Perform anamnesis for assessment of the patient for the presence of signs and symptoms of COVID-19, with careful tracking of all professionals who were in contact with a COVID-19 positive individual.(3,5–9,11,19) In this context, attention should be paid to the suspicious signs of COVID-19: fever> 37.8ºC, conjunctivitis, chill, cough, shortness of breath, fatigue, muscle or body pain, headache, loss of taste or smell, sore throat, congestion or runny nose, nausea, or vomiting, diarrhea, which appear 2 to 14 days after exposure to the virus. The presence of indicative signs of severity for COVID-19 should be assessed, including: breathing difficulties, persistent pain or pressure in chest, confusion, difficulty keeping awake and bluish lips.(3,6,9,25,31,32) |
| Check the real need for a face-to-face consultation, through an anamnesis focused on the basic concepts of:* *Emergency:* situations involving the risk of death of the patient, such as airway obstruction and uncontrolled hemorrhage.
* *Urgency:* refers to cases of severe pain and/or infection.
* *Elective procedure:* refers to the scheduled consultation where there is no setting that requires emergency.(3,6,7,9,11,26)

If available, use Teledentistry, which includes remote patient assessment and medication prescription. This remote prescription includes analgesics, anti-inflammatory and/or antibiotics, according to the disease condition, patient preferences, possible complications and, the possibilities coming from the local public health departments.(5,11)Special attention should be given to elderly and/or comorbid patients: if asymptomatic for COVID-19, only urgent or emergency care should be prioritised and, if available, the possibility of home care should be considered. In turn, if infected with COVID-19, the elderly and/or comorbid patient should be referred to a hospital to assess the risk and benefit of urgent or emergency dental care.(11) |
| Anamnesis should be repeated for each new patient consultation request.(11) |
| **Care in the face-to-face appointment** | Patient must wear a face mask and perform hand hygiene with soap or alcohol 70º. (3,6,7,9,11) |
| Perform temperature measurement, and, if >37.8ºC considers fever. (6,7,9,19) |
| Check oxygen saturation levels with pulse oximeter and, if <93% refer to medical care due to the risk of silent hypoxemia.(27–29) |
| Repeat the triage anamnesis for COVID-19 before appointment.(5,11) |
| Consider the use of a rapid test for COVID-19 since it has high specificity and sensitivity.(6) |
| Use of FFP2, N95 or FFP3 respirators for procedures without aerosol generating procedures (AGP). However, in suspected or confirmed cases of COVID 19 and/or for any procedures with AGP, it is ideal to use respirators, FFP3, N99 or N100 without exhalation valves.(3,6,8,11,19,30) |
| Priority should be given to emergency and urgent care, postponing elective procedures, avoiding adverse impacts on the patients’ conditions due to delayed care. If possible, carry out the entire treatment in a single consultation.(3,6,9,11,19) |
| Preferably, perform minimally invasive procedures such as using excavators, chemical agents for tooth decay removal and rubber dam to minimize the spread of microorganisms.(3,5,7,8,11,19) |
| Avoid procedures that produce aerosol (e.g. dental turbines, micro motor hand piece, ultrasonic scalers, air/water syringe and sodium bicarbonate powder jet), or procedures that lead to increased salivation, retching or coughing as an intraoral radiographic examination and impression. Otherwise, tomography or extra oral radiographic technique should be used. (3,5–8,11,19) |
| Use personal protective equipment (PPE) such as: goggles, face shields, gloves, apron, long sleeved disposable fluid repellent, coverall, surgical cap and, foot cover, in addition to adoption of work uniform (consider washing the uniform using the hospital services or specialised laundry facilities).(3,6–9,11,19) Change PPE at each appointment to avoid cross-contamination and spread of infection.(7,11) |

In the context of teletriage, it is necessary to direct the anamnesis to cover the need for dental intervention against the risk of COVID-19 infection, mainly with regards to the general health of the patient. Therefore, social distancing must be strictly applied with special preparations for the high-risk patient groups such as the elderly and those suffering chronic diseases, who might suffer serious life-threatening condition on top of COVID-19 infection. As hypoxemia can be silent in some patients, the measurement of oxygen saturation, which is a part of the first protocol, represents an important screening tool for conditions that may potentially predispose to severe complications when combined with COVID-19 infection.(27,28) Likewise, we have included conjunctivitis as an important clinical sign because it may represent the only clinical sign of COVID-19. In addition, due to the dentist working close to the eye region, the need to use goggles and face shield is evident.(25,31,32)

In relation to the personal protective equipment (PPE), despite the scarcity of resources, a robust scientific evidence regarding the reuse of PPE in a safe way is currently unavailable. Therefore, the current recommendation is to change these after each patient.(33) The recently developed health and safety guidelines in the dental field seem to be directed only towards the prevention of a singly viral type, ignoring the provision of protective measures against biological hazards other than COVID-19. Importantly, the presence of viable SARS-CoV-2 in aerosol and on copper has been reported for 3 hours, on wood and fabrics for at least 24 hours, on glass for 48 hours, on stainless steel and plastic for 96 hours, and on external surface of a surgical mask for up to 7 days.(34,35) Thus, in the dental environment we there is wood (cabinets), stainless steel, copper (electrical components), non-woven fabric for PPE, fabrics (clothing), plastic and glass where, SARS -CoV-2 has different stability.(19,34) Therefore, the strict disinfection and sterilisation of these materials require different disinfection or sterilisation techniques to ensure the proper maintenance of these valuable resources and preventing their damage.(19) Furthermore, a new design of dental equipment is necessary in order to minimise the exposure of different materials to contact with biological samples, mainly from aerosol and droplets, unifying the standards of protection, disinfection and, sterilisation.

COVID-19 exposed the inadequacy and defects in the regulations upon which the dental biosafety was based.(3,26) The indication of the use of respirators in the guidelines is only superficially justified based on the scarcity of PPE. Thus, if the indication of a given respirator is based on the viral size, we must consider that hepatitis B virus (HBV) with 40nm is much smaller than SARS-CoV-2 with 60 to 140nm, and accordingly, will be more needy of face masks to prevent its transmission than SARS-CoV-2. Otherwise, if the need to use a respirator is based on the risk of the aerosol-mediated viral transmission, it should be noted that, based on the recently accepted hypothesis, the prions can be transmitted by aerosols, which are much smaller than a virus.(36,37) In addition, the literature describes the possibility of transmission of COVID-19 infection by asymptomatic carriers, which, without testing, implies that everyone must be treated as a COVID-19 patient.(5,18,38,39) Perhaps the optimal solution to a shortage of PPE supplies is to expand production by industries and not reuse. Therefore, non-reusable face masks with the highest level of protection are urgently needed to combat other pathogenic threats besides SARS-CoV-2, especially that there are no solid scientific basis for processes or conducts that guarantee a wide decontamination regarding all pathogenic types.(33,36,37,40) Similarly, there is a need to develop reliable rapid tests that allows for massive testing and can be used by the dentists, knowing that the current real-time reverse transcription polymerase chain reaction (RT-PCR) COVID-19 test is not feasible for immediate results and subsequent management actions.(4,5,41)

**Multilevel perspectives and guidelines for Dentistry Education**

Table 3 indicates the main guidelines for continuity dental education in Dentistry.(3,4,11,26,42)

**Table 3: The main guidelines for continuity dental education in Dentistry.**

|  |  |
| --- | --- |
| **MODALITY** | **Features** |
| **Theoretical classes** | Maintaining remote online activities, preferably with live classes to promote students/lecturers interaction.(3,26) |
| Use of educational tools such as participation in online seminars, case-based discussions or problem-based learning, and clinical videos.(26) |
| **Laboratory classes** | Pre-clinical didactic videos.(26) |
| Use of PPE suitable for staff and students. Maintaining social distance of 2 meters, imposing physical barriers and insuring appropriate levels of air flow.(26) |
| Use of virtual reality tools if available.(26) |
| **General measures** | Insuring that preventive and therapeutic psychological support are in place for students against psychological stress, anxiety and fear caused by the uncertainties arising from the COVID-19 pandemic.(3,26) |
| **Clinical Practices** | It should be understood that the techniques of provision of the clinical care is the main component in the training of students in Dentistry.(26) Thus, these activities can be postponed but preparations should be made to deliver sufficient clinical training in an optimal way when it is safe to do so. |
| It should be acknowledged that there is no way that virtual, online or remote tools can replace face-to-face clinical care activities.(26) |
| Consider the recommendations of PPE, engineering controls, proper social distancing and patient flow for cases of clinics with multiple chairs.  |
| Whenever possible, face-to-face urgent and emergency care should be considered. Special measures should be put in place in case of infected or suspected patients with COVID-19, ensuring strict social distancing and anti-infection measures are taken. Another technique worthy of implementing is to divide the patients into groups based on the presence or absence of aerosol generation. They then should be directed into different areas within the practice room. The separation of patients should minimise the risk of spread of COVID-19 as well as enables tracking in case of contamination.(3,26)Similarly, the service teams should be separated to reduce the risk of infection and to facilitate contact tracking in the event of contamination. Thus, a lecturer should be kept in tutoring a specific and reduced number of students.(11) |
| The temperature should be checked and the anamnesis performed daily, regarding the signs and symptoms of COVID-19, maintaining confirmed and suspicious cases, as well as professors, students and patients from risk groups at home and, when necessary, under medical care.(11) |
|  | Consider using rapid tests for COVID-19 on staff and patients.(26) |
| **Continuing education** | Strong migration trend from traditional congresses to webinars and online courses.(4,42) |
| Use of online tools that allow audio-visual interaction in real time.(42) |

Dental education was also massively affected by the COVID-19. In this scenario, the resumption of lecturers/students interaction in a virtual environment is extremely important. Furthermore, resumption of laboratory activities requires basic measures of biosafety/risk assessment and social distance. However, restart of essential clinical activities for training depends on the behaviour of the pandemic in each region and must be carefully weighed and planned for in order to guarantee the safety of all involved, be it employees, dental staff and patients. All measures essential to the proper and safe functioning of dental services must be readjusted and strictly applied to the current clinical practices environment. Thus, in the context of continuing education, there should be a reduction in courses and face-to-face sessions due to measures of social distancing, which, should be partially replaced by webinars and online courses. Nevertheless, mechanisms for validating the information presented in these webinars must be defined as many have dubious quality and are based on anecdotal evidence.(4)

Notoriously, the COVID-19 pandemic has an ambiguous character for Dentistry. An example of a negative impact of the COVID-19 pandemic in Dentistry is upon determination of suspension or reduction of services and, the increase in the level and number of required biosafety artefacts, with consequent scarcity and increased costs of PPE. This will negatively impact the economic feasibility of the profession. (4,17,19,43) On the other side, positively, the pandemic exposed the fragility of the currently prevailing biosafety rules, which will gradually require the generation of new knowledge and adjustment. In addition, the need for rapid testing of the population, can open new opportunities for Dentistry due to the ease of collecting salivary samples. Therefore, there are various questions related to the anti-infection measures, which needs to be addressed through robust scientific research. This include the need for answers regarding the feasibility of PPE reuse, decontaminating or sterilising while maintaining normal functionality with no occupational health risks, and cross-transmission of infection while seeking to save the expensive and scarce PPE. Another question is to address is which paths should be followed to reduce the aerosol generation, and if there are possible new less invasive techniques or devices that capture and decontaminate the aerosol. Also, what is the ideal configuration of a dental chair and peripheral dental equipment in order to standardise and optimise the cleaning and decontamination measures? Importantly, what is the ideal architecture and temporal flow of patients that allows for optimal biosafety, and what is the ideal level of a respirator in dental practice? In fact, COVID-19 showed that Dentistry was spending most of its resources on knowledge and innovation of products, techniques and procedures, while forgetting to innovate and develop a safe work environment for professional practice.

**Conclusion**

Thus, the drastic effects that COVID-19 imposes on the dentistry profession can be the strongest motivation that may lead to the development of definitive and innovative solutions for a true biosafety in Dentistry.

**References**

1 World Health Organization - WHO. WHO Director-General’s opening remarks at the media briefing on COVID-19 - 11 March 2020. https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (accessed 8 Aug2020).

2 Lau H, Khosrawipour V, Kocbach P *et al.* The positive impact of lockdown in Wuhan on containing the COVID-19 outbreak in China. *J Travel Med* 2020; **27**. doi:10.1093/jtm/taaa037.

3 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**: 481–487.

4 Views from around the world. *Evid Based Dent* 2020; **21**: 39–41.

5 Alharbi A, Alharbi S, Alqaidi S. Guidelines for dental care provision during the COVID-19 pandemic. *Saudi Dent J* 2020; **32**: 181–186.

6 Centers for Disease Control and Prevention - CDC. Guidance for Dental Settings. 2020.https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html#PPE (accessed 21 May2020).

7 American Dental Association - ADA. As Dental Practices Resume Operations, ADA offers Continued Guidance Recommendations include changes before, during and after appointments to protect patients and dental team. 2020.https://www.ada.org/en/press-room/news-releases/2020-archives/may/as-dental-practices-resume-operations-ada-offers-continued-guidance?utm\_source=cpsorg&utm\_medium=cpsalertbar&utm\_content=cv-continuedguidance-statement&utm\_campaign=covid-19# (accessed 8 Aug2020).

8 Occupational Safety and Health Administration - OSHA. COVID-19 - Control and Prevention | Denstistry Workers and Employers | Occupational Safety and Health Administration. https://www.osha.gov/SLTC/covid-19/dentistry.html (accessed 8 Aug2020).

9 Gugnani N, Gugnani S. Safety protocols for dental practices in the COVID-19 era. *Evid Based Dent* 2020; **21**: 56–57.

10 Ather A, Patel B, Ruparel NB, Diogenes A, Hargreaves KM. Coronavirus Disease 19 (COVID-19): Implications for Clinical Dental Care. *J Endod* 2020; **46**: 584–595.

11 National Health Service - NHS. COVID-19 guidance and standard operating procedure For the provision of urgent dental care in primary care dental settings (from 8 June 2020) and designated urgent dental care provider sites. 8 June 2020. 2020; : 35.

12 World Health Organization - WHO. Oral health. https://www.who.int/health-topics/oral-health/#tab=tab\_1 (accessed 15 Aug2020).

13 Peres MA, Macpherson LMD, Weyant RJ *et al.* Oral diseases: a global public health challenge. *Lancet* 2019; **394**: 249–260.

14 Andrade SA, Pratavieira S, Ribeiro MM, Bagnato VS, de Pilla Varotti F. Oral cancer from the perspective of wide-field optical fluorescence: Diagnosis, tumor evolution and post-treatment follow up. *Photodiagnosis Photodyn Ther* 2017; **19**: 239–242.

15 Andrade SA, Melo PL de, Campos HF *et al.* Correlation between oral squamous cell carcinoma stage and its clinical signs and symptoms. *F1000Research* 2019; **8**. doi:10.7490/F1000RESEARCH.1117776.1.

16 Andrade SA, Ferreira BCD, Costa IS *et al.* Comparative study between the main clinical characteristics, risk factors and prognosis of conventional oral squamous cell carcinoma and its variant forms. *F1000Research* 2020; **9**. doi:10.7490/F1000RESEARCH.1118241.1.

17 Coulthard P. Dentistry and coronavirus (COVID-19) - moral decision-making. *Br Dent J* 2020; **228**: 503–505.

18 Working group publishes rapid review for re-opening dental services. *Br Dent J* 2020; **228**: 743–743.

19 Clarkson J, Ramsay C, Aceves M *et al.* Recommendations for the re-opening of dental services: a rapid review of international sources (substantial update 16 May 2020). *Cochrane Database Syst Rev* 2020.

20 Gold MS, Sehayek D, Gabrielli S, Zhang X, McCusker C, Ben-Shoshan M. COVID-19 and comorbidities: a systematic review and meta-analysis. *Postgrad Med* 2020; : 1–7.

21 Guan W, Liang W, Zhao Y *et al.* Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. *Eur Respir J* 2020; **55**: 2000547.

22 Yang J, Zheng Y, Gou X *et al.* Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. *Int J Infect Dis* 2020; **94**: 91–95.

23 Zhou F, Yu T, Du R *et al.* Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020; **395**: 1054–1062.

24 Li X, Xu S, Yu M *et al.* Risk factors for severity and mortality in adult COVID-19 inpatients in Wuhan. *J Allergy Clin Immunol* 2020; **146**: 110–118.

25 Loffredo L, Pacella F, Pacella E, Tiscione G, Oliva A, Violi F. Conjunctivitis and COVID‐19: A meta‐analysis. *J Med Virol* 2020; **92**: 1413–1414.

26 Iyer P, Aziz K, Ojcius DM. Impact of COVID-19 on dental education in the United States. *J Dent Educ* 2020; **84**: 718–722.

27 Tobin MJ, Laghi F, Jubran A. Why COVID-19 Silent Hypoxemia Is Baffling to Physicians. *Am J Respir Crit Care Med* 2020; **202**: 356–360.

28 Teo J. Early Detection of Silent Hypoxia in Covid-19 Pneumonia Using Smartphone Pulse Oximetry. *J Med Syst* 2020; **44**: 134.

29 Dondorp AM, Hayat M, Aryal D, Beane A, Schultz MJ. Respiratory Support in COVID-19 Patients, with a Focus on Resource-Limited Settings. *Am J Trop Med Hyg* 2020; **102**: 1191–1197.

30 Centers for Disease Control and Prevention - CDC. Strategies for Optimizing the Supply of N95 Respirators: COVID-19 | CDC. https://www.cdc.gov/coronavirus/2019-ncov/hcp/respirators-strategy/index.html (accessed 19 Aug2020).

31 Hu K, Patel J, Patel BC. *Ophthalmic Manifestations Of Coronavirus (COVID-19)*. 2020http://www.ncbi.nlm.nih.gov/pubmed/32310553.

32 Scalinci SZ, Trovato Battagliola E. Conjunctivitis can be the only presenting sign and symptom of COVID-19. *IDCases* 2020; **20**: e00774.

33 Rubio-Romero JC, Pardo-Ferreira M del C, Torrecilla-García JA, Calero-Castro S. Disposable masks: Disinfection and sterilization for reuse, and non-certified manufacturing, in the face of shortages during the COVID-19 pandemic. *Saf Sci* 2020; **129**: 104830.

34 Chin AWH, Chu JTS, Perera MRA *et al.* Stability of SARS-CoV-2 in different environmental conditions. *The Lancet Microbe* 2020; **1**: e10.

35 van Doremalen N, Bushmaker T, Morris DH *et al.* Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *N Engl J Med* 2020; **382**: 1564–1567.

36 Stitz L, Aguzzi A. Aerosols. *Prion* 2011; **5**: 138–141.

37 Haybaeck J, Heikenwalder M, Klevenz B *et al.* Aerosols Transmit Prions to Immunocompetent and Immunodeficient Mice. *PLoS Pathog* 2011; **7**: e1001257.

38 Liang TJ. Hepatitis B: The virus and disease. *Hepatology* 2009; **49**: S13–S21.

39 Zhu N, Zhang D, Wang W *et al.* A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med* 2020; **382**: 727–733.

40 Ryou C. Prions and prion diseases: fundamentals and mechanistic details. *J Microbiol Biotechnol* 2007; **17**: 1059–70.

41 Tang Y-W, Schmitz JE, Persing DH, Stratton CW. Laboratory Diagnosis of COVID-19: Current Issues and Challenges. *J Clin Microbiol* 2020; **58**. doi:10.1128/JCM.00512-20.

42 Porpiglia F, Checcucci E, Autorino R *et al.* Traditional and Virtual Congress Meetings During the COVID-19 Pandemic and the Post-COVID-19 Era: Is it Time to Change the Paradigm? *Eur Urol* 2020; **78**: 301–303.

43 McMahon DE, Peters GA, Ivers LC, Freeman EE. Global resource shortages during COVID-19: Bad news for low-income countries. *PLoS Negl Trop Dis* 2020; **14**: e0008412.