

ORIGINAL ARTICLE

Dental education in the time of SARS-CoV-2

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Abstract

Introduction: The SARS-CoV-2 virus has forced profound change on all aspects of society, with significant impact on dental education. Dental students like all other dental clinical personnel are considered to be at the highest risk amongst healthcare workers due to the nature of treatment, namely, working in the oral cavity (known reservoir for the virus) and the routine use of aerosol-generating procedures. The nature of this pandemic has created several challenges to dental clinical education. The aim of this paper is to discuss these challenges and how educators have sought to overcome them.

Materials and Methods: This paper reviews the evidence base around bio-aerosol and infection control measures specifically in the context of dental education.

Results: Using current knowledge of bio-aerosol and increasing understanding of the virus, dental educators can implement evidence-based measures to ensure safe teaching within both simulation and clinical environments.

Discussion: This paper contextualises the current pandemic in a dental education setting by providing a critical appraisal of the challenges posed by SARS-CoV-2 and how these challenges may be managed.

Conclusion: The SARS-CoV-2 pandemic has created unique challenges for dental schools worldwide. Dental educators have sought to identify these challenges and find solutions appropriate to the stage of the pandemic specific to their geographical location.

KEYWORDS

aerosol, clinical teaching, COVID-19, dental education, simulation

1 | INTRODUCTION

On 11 March 2020, the World Health Organization (WHO) declared the SARS-CoV-2 virus, more commonly known as COVID-19 as a pandemic. At the time of writing (9 September), SARS-CoV-2 cases have been diagnosed on every continent (except for Antarctica) with more than 27.5 million confirmed cases and almost 900 000 deaths worldwide.¹ This virus has forced profound change on all aspects of society, with significant impact on the dental profession including dental education.

The SARS-CoV-2 virus has diverse clinical presentation ranging from mild, non-specific symptoms such as dry cough, fever or malaise to more severe symptoms like respiratory distress, which is more often seen in populations with comorbidities.² The median incubation time is estimated to be 5.1 days, and the majority of patients (97.5%) will develop symptoms within 11.5 days.³ Transmission can occur when a carrier is pre-symptomatic or has no symptoms at all, and this is more commonly seen amongst younger demographics where the overall course of the infection is generally mild.⁴ This virus is transmitted via respiratory droplets and contact transmission, with

increasing evidence of aerosol transmission, resulting in updated recommendations from the Centers of Disease Control recommending the use of face masks in public.^{5,6} The nasopharynx complex serves as a reservoir for SARS-CoV-2^{7,8}; thus, transmission may also occur via respiration, speaking, coughing or sneezing.^{9,10} The provision of dental treatment in this context is fraught due to close physical proximity to the oral cavity and the number of dental procedures that will aerosolise the virome.^{11,12} Dental clinical personnel (dentists, oral health therapists, auxiliaries) are considered at the highest risk amongst healthcare workers in terms of frequency of exposure and physical proximity to others.¹³ In undertaking their dental studies, student clinicians face the same inherent risks as all dental healthcare workers (HCW). Therefore, SARS-CoV-2 has created a number of unique challenges for dental educators which require careful consideration in balancing the safety of students and staff and the adoption of wider public health measures whilst providing high standards of dental education. The aim of this paper is to discuss the impact of the current pandemic on dental clinical education.

2 | SARS-COV-2: IMPLICATIONS FOR CLINICAL TEACHING

Dental education is a unique combination of didactic, simulated learning and clinical practice where experience and time are crucial in building the professional of the future. In these unprecedented times, the limitations of gaining authentic learning experiences weigh heavily on dental educators and students. The most notable challenges facing clinical education include the vast number of bio-aerosol-generating procedures undertaken in a large, open-plan clinical teaching facility or simulation clinic, the difficulty in implementing social distancing due to the nature of care provided, implementing additional infection control procedures and altering administrative controls in a learning environment.

2.1 | Dental Bio-aerosol

Aerosol or more specifically, bio-aerosol contains an array of organisms within small particles named droplet nuclei ($1 \pm 5 \mu\text{m}$) or droplets ($>5 \mu\text{m}$).¹⁴ Whilst larger droplets fall to the ground quickly due to gravity, droplet nuclei have a low settling velocity and are airborne for a longer time with the ability to travel further before entering the respiratory tract or contaminating surfaces.¹⁵

Routine dental treatment involves a range of mechanical instrumentation (air turbine and rotary handpieces, air abrasion, ultrasonic scalers) and the air-water (triplex) syringe which generate bio-aerosols. The majority of investigations into quantifying bio-aerosol generation by different instruments are not contemporary, even so, the findings are pertinent when operating in this pandemic. Almost all dental procedures produce a bio-aerosol including examination and hand scaling which many clinicians would consider innocuous.¹⁶ However, the focus of previous studies is almost exclusively on

ultrasonic scaling, which produces up to 3 times the rate of bacterial aerosol compared to operative procedures.^{17,18} A number of studies indicate the use of high volume evacuation (HVE) significantly reduces production of bio-aerosol in the environment.^{12,19-21} This has specific implications for student clinicians who often work independently and may prefer the lighter more manoeuvrable (but less efficient) saliva ejector over the bulky HVE, thus, increasing bio-aerosol exposure in the clinical teaching space.

2.2 | The teaching space

Most clinical educational facilities are open floor plan with cubicles which maximises the number of chairs. There are several advantages to these designs, notably, patient safety as teaching staff have direct oversight of most of their students. However, a significant drawback is the generation, volume and spread of bio-aerosol due to the large number of operators in these spaces. Droplet nuclei within dental bio-aerosols stay airborne for up to 2 hours,²² transport over long distances and contaminate surfaces when the particles settle.¹⁴ The contaminated zone is defined as the area which becomes contaminated by splashes, droplets and bio-aerosol originating from the patient's mouth²³ with studies showing this can be distance of up to 2.4 m in an open-plan teaching clinic compared to 1.5 m in a single surgery.^{18,24-26} Current understanding is that SARS-CoV-2 has sustained infectivity in aerosol with a half-life of 90 minutes.²⁴ This has implications in a clinical education setting where large numbers of people congregate including patients and families, students, auxiliary staff and clinical supervisors. Bio-aerosol is created, through respiration, speaking, coughing, sneezing and generated by numerous dental procedures occurring concurrently, resulting in significantly increased exposure.

Bio-aerosol is also created in the simulation setting though it is considered much lower risk as it is not patient derived. However, recent studies indicate there is aerosolisation of virus from respiration¹⁰; thus, the simulation setting has the potential to be a high-risk environment for transmission of SARS-CoV-2. Within this populated space, dental aerosol becomes bio-aerosol due to the presence of students and staff. Decreane et al emphasised in their investigation of airborne bacteria in a hygiene school (open plan, 10 chairs) that the 10-fold increase in colony forming units identified during clinical periods compared to clinically non-active periods was not just due to aerosol-generating procedures (AGP) but because of the number of people in the teaching space.²⁶ Other factors that make this setting potentially high risk include close physical proximity of students to each other (due to "chair" configurations such as the popular pod or bench designs) and educators. Supervisor/student interactions when assessing procedures and providing feedback are key to the educational process and require contact that regularly encroaches personal space.

This virus is particularly dangerous to subsets of the population including those with existing comorbidities and the older demographic.²⁷ Most of the student body are young and healthy; however,

educators need to consider the safety of students who have at-risk medical conditions such as diabetes or asthma which may not have otherwise impacted the course of their studies. The current pandemic has also focused on an ongoing issue in dental academia—the shrinking pool of educators and the “ageing of the dental faculty”.²⁸ Dental education relies on highly experienced teaching staff. Clinical educators aged 60 years and over are at a higher risk of SARS-CoV-2.²⁹ The safety and well-being of staff is paramount to high quality education; therefore, isolation of at-risk groups will result in further reductions to an already diminished group of educators.

Finally, consideration must be given to ventilation systems in the teaching space. Studies in the dental setting are limited to closed door investigations which found that the ventilation system within the surgery was critical to aerosol dissipation.^{17,18,30} However, most dental clinics, indeed dental hospitals, are not negative pressure environments. In the 2003 SARS-CoV-1 outbreak in Hong Kong, the virus spread through the ventilation system of an apartment building.¹² There are indications that SARS-CoV-2 behaves similarly as a Chinese case study reported spread of the virus via air-conditioned ventilation⁹ in addition to studies from hospitals in Wuhan (the epicentre of this pandemic) where the virus was detected in air outlet filters.³¹ Therefore, potentially infected air may be transported beyond the vicinity of student clinical teaching facilities.

2.3 | Infection control

It is considered the norm that dental practices and hospitals adhere to strict infection control procedures based on standard precautions to prevent transmission of disease, keeping HCWs and patients safe and healthy.³² The nature of transmission of the SARS-CoV-2 virus requires additional and specific measures (transmission-based precautions)³³ to manage bio-aerosol. The most effective method used by several countries in recent months involved severely limiting the delivery of dental services as occurred in March and April in Australia where dentistry was restricted to non-AGP treatments with exceptions for treatment of acute dental pain, trauma and for medically necessary dental care.³⁴ This resulted in the virtual shut down of routine dental care.

However, events leading up to this time were difficult, characterised by lack of knowledge (or worse, misinformation) about the virus and the wider implications for society. Unlike other university students, dental and oral health students are essentially unregistered clinicians who work under close supervision. Dental schools must ensure the safety of the student clinicians whilst considering their training. The most prudent action undertaken over the last few months by several dental schools worldwide was to close as various public health measures ranging from voluntary to mandated lockdowns took effect.

Clinical educational facilities are considered at higher risk of being hubs of transmission due to the factors discussed above; therefore, infection control procedures need to be maintained at the highest standard. The current pandemic has tested the agility

of large institutions to adapt to the literature available regarding the virus to ensure that the guidelines developed are evidence-based and practical. Laboratory testing has shown that SARS-CoV-2 is stable for up to 72 hours on stainless steel and plastic surfaces.²⁴ These are the most common surfaces found in a dental surgery and have profound implications in student clinics. This finding requires reconfiguration of expansive clinical and non-clinical areas, limiting dental materials and equipment that are stored on benchtops and banning educational material (folders, books, electronic devices). Extra attention is required to effectively clean clinical and non-clinical areas between appointments using disposable, single use wipes with approved hospital grade disinfectant that is effective against other viruses such as norovirus or >60% alcohol based wipes or 0.1% sodium hypochlorite.³⁴ Dental schools often operate over several clinical sites. It is imperative to develop consistent guidelines for all clinical placements to ensure that students are not confused and thus do not compromise infection control procedures especially at this critical time.

3 | RESUMING CLINICAL TEACHING: ADDRESSING THE CHALLENGES

The decision to resume clinical teaching activities is complex and informed by the current status of the virus and government policies to manage it. Dental academics need to ensure a safe return to teaching for students, patients and staff with contingency plans (creation of 2 teaching teams to ensure uninterrupted teaching) as SARS-CoV-2 is highly contagious⁹ and the status of virus transmission in the community is volatile.

3.1 | Clinics

The main challenges in student clinics are to manage bio-aerosol, ensure student and staff compliance with the required additional infection control measures, implement social distancing policies to reduce over population in the teaching space and thus reduce exposure to others as well as the bio-aerosol created.³⁵

3.1.1 | Bio-aerosol reduction

Reduction in bio-aerosol can be achieved in several ways including using a pre-procedural mouth rinse (1% hydrogen peroxide, 0.2% povidone iodine or alcohol free options such as 0.2% chlorhexidine rinse or an essential oil) to reduce the bacterial burden³⁴ as well as the use of rubber dam when possible and if appropriate.¹² Rostering clinical pairs reduces bio-aerosol production and dissemination as the student who acts as an auxiliary, provides HVE for all procedures and a dedicated auxiliary will shorten the length of the clinical session. Student appointments take significantly longer (2-3 hours) than those of experienced clinicians which exposes both patients and

HCWs to bio-aerosol for longer periods of time. It is therefore prudent to prioritise final year students in the clinical setting as the most experienced clinical cohort with more efficient clinical skills.

3.1.2 | Compliance with additional infection control measures

Additional infection control measures begin before entry into the teaching facility with screening of staff, students and patients, including temperature check, questionnaire of respiratory symptoms or fever.³⁶ Larger institutions require more stringent infection control procedures, often operating at restriction levels higher than private practice.³⁷ Most educational clinical facilities will follow measures outlined in combined transmission-based precautions which include contact, droplet and airborne precautions in addition to standard precautions.³³ These measures (for all clinical personnel, including educators) mandate the use of disposable surgical caps and long-sleeved polyethylene gowns with elasticised wrists which are carefully removed and disposed of after every patient. In some facilities, educators are asked to change gowns between each student/patient or patients are asked to wear gowns. The latter option is preferred and supported by a recent whole genome sequencing (assessment of culturable and non-culturable bacteria) study looking at bacterial load, composition and spatial distribution of bio-aerosols in dental clinics, including university clinics, which found that the highest contamination was found around the patient's chest area.³⁸

All dental personnel are required to wear a surgical mask or N95/P2 respirators when undertaking an AGP.³⁹ The N95/P2 surgical respirators provide more effective protection from airborne particles (0.3-0.6 μm) and from liquid contaminating the face.⁴⁰

Effective eye protection is also necessary as the virus has been identified in conjunctival samples from SARS-CoV-2 positive patients.⁵ A study assessing the amount of organic residue (equivalent to bacterial burden) within the contamination zone found the most organic residue post-treatment on operator eyewear.⁴¹ In this investigation, students were asked to wear eye protection (goggles) and a facemask with shield. This reinforces that a face shield alone is insufficient protection against bio-aerosol and this virus.

Studies to date show that whilst students have a positive attitude to infection control, their compliance is poor, particularly around eye protection, with 28% of senior students in a Saudi Arabian dental school admitting to only wearing eye protection sometimes in a wide ranging questionnaire of clinical practice.⁴² These findings have been replicated in other studies^{43,44} and indicate that students struggle with adhering to infection control directives. Additional measures will be onerous for students but are necessary to ensure safe delivery of dental care during a pandemic characterised by a highly contagious airborne virus. Most clinical assessments of student performance include compliance with infection control as a basic requirement of dental care. This is necessary to ensure students understand their infection control obligations in terms of patient safety on graduation.

3.1.3 | Social distancing

The nature of dental care and clinical teaching is not conducive to social distancing, but measures can control the number and flow of patients through the student clinics by limiting only one patient appointed in each clinical session which ensures that there is sufficient time between patients to facilitate appropriate distancing between consecutively appointed patients for student clinics (and adjacent clinics) and to provide sufficient time for thorough decontamination of clinical areas prior to the next patient. Further measures include restricting the number of patients allowed to sit in the waiting room to those who have mobility impairment or those who do not have personal vehicles. Patients who have arrived in personal vehicles should be advised to remain in the car until called by the student clinician. Only the patient will be escorted into the clinics after completing screening procedures and checking in with reception. A strict ratio of students/staff per session must be devised based on factors including complying with person/m² restrictions which would require the use of every second or third chair in the teaching space and ensuring provision of effective clinical oversight for each student in a shorter clinical session.

3.2 | Simulation clinics

The primary goal of simulation learning is to master the motor skills required to perform a variety of dental procedures in a low risk, authentic setting.⁴⁵ As discussed previously, operation of the simulation clinic during this current pandemic is challenging as this educational space has the potential to be a high-risk setting for the transmission of SARS-CoV-2. Therefore, as with clinics, consideration needs to be given to bio-aerosol reduction, infection control measures and social distancing with appropriate modifications as this is not a patient setting.³⁵

Bio-aerosol reduction and social distancing is achieved by reducing the number of students rostered to the simulation clinic. Smaller student numbers mean, less teaching staff are required thus, maximising mandated distancing between individuals, whenever possible. This also means less bio-aerosol is produced through respiration and speech (teaching and feedback). Bio-aerosol production is further reduced as fewer students are undertaking AGP. Directives will be required to discourage students and staff from mingling or congregating in open areas and to leave the facility promptly at the end of the session. The simulation clinic requires a single entry and exit point for students/staff to monitor personnel flow and ensure only authorised personnel enter the area.

Working in the simulation clinic is critical for students to understand, apply and reinforce their foundation knowledge in infection control. When resuming teaching, the only additional measures to standard precautions would be the screening of staff and students on entering the facility. As noted above, student compliance in infection control can be unreliable when seeing patients. It is logical to expect that non-compliance will be higher in simulation clinics

where the perceived risk of disease transmission is diminished. It is especially critical given the current crisis that there is full compliance with infection control in the simulation setting to reduce the risk of transmission of SARS-CoV-2 and ensure correct application when exposed to patients. Thus, it is the responsibility of dental educators to ensure that the simulation clinics operate under strict infection control parameters (which should be assessed as part of the teaching session) as expected in clinic. This ensures that strict infection control standards are practised by students regardless of their educational setting and into the future.

In the senior years, the focus on simulation learning is reduced as students' progress onto treating patients. Cessation of clinical teaching due to SARS-CoV-2 has seen the teaching focus return to simulation as dental educators seek authentic teaching alternatives to clinical teaching. It is important to recognise that simulation teaching cannot substitute the experience of treating patients. Obvious limitations of this type of teaching include lack of patient-clinician communication, pain management, management of saliva and blood, interaction with biological tissues (tooth structure, gingiva) and pathology such as caries. Simulation learning is based on the transfer of learning theory where "the training of one motoric task leads to significant improvement in performance of another motoric task that has similar components"⁴⁵; thus, the objective of simulation teaching in senior years during this pandemic is the honing of motor skills through repetition, with students required to complete complex procedures that mimic clinical situations to ensure maintenance of their skill level.

The disruption to teaching caused by the pandemic has resulted in the adoption of several different teaching styles predominated by various online platforms.⁴⁶ Whilst dental education has embraced this, there are obvious limitations for learning fine motor skills and applying that in clinics. It would be timely to consider providing activities at home to practise motor skills. This is especially pertinent for junior years who have endured substantial loss of simulation clinic time and no clinical time as teaching of final year students are prioritised during this current crisis. The lost art of wax carving should be actively considered. This provides students with a working understanding of tooth anatomy and the ability to carve (amalgam) or shape (composite resin) materials, thus, restoring form and function of anterior and posterior teeth. It also provides insight into understanding basic laboratory techniques used for indirect restorations. A Canadian study assessed student performance of wax carving using the combination of a didactic lecture and a practical exercise using carving and found it be an effective method of learning.⁴⁷ This study was conducted in 2013, when face-to-face teaching was the norm, but this method could be easily adapted to suit today's circumstances with online lectures and students' practicing at home. This would also be relatively low cost for students and easily sourced compared to other portable tools like a small motor to work on models or "PhantHome" which was developed in Israel for the purpose of home training students in basic motor skills.⁴⁵

4 | FUTURE PROOFING

The global community was not prepared for SARS-CoV-2 and its devastating impact. Scientists warn that this is not a black swan event and more pandemics will emerge as humans encroach upon and destroy natural habitats.⁴⁸ Therefore, it is imperative that there is dissemination of information about how various dental schools around the world have responded to the pandemic. A recent publication compares the experience of 3 dental schools in Brazil, Pittsburgh and Australia and astutely concludes "dealing with dental education depends on the stage of the epidemic and the characteristics of each country".⁴⁶ This emphasises that a global approach is required and at the end of this pandemic there will be vast amounts of experience and data indicating how dental education overcame challenges posed by the pandemic.

SARS-CoV-2 has also highlighted the paucity of evidence for infection risk associated with AGPs in dentistry, especially in clinical education settings, as closed room private practice investigations cannot be meaningfully extrapolated.⁹ These gaps in evidence have produced a vacuum in knowledge which is detrimental to best practice.⁴⁹

Broader considerations about the design of new educational facilities must consider clinical teaching spaces which should ideally operate under negative air pressure or at a minimum have a conventional air system with no air recycling, that is 100% fresh air to dissipate bio-aerosol effectively.^{9,22} It may even be appropriate to consider eliminating bio-aerosol when using mechanical instrumentation. A recent *in vitro* study demonstrated that a polymer admixture irrigant (instead of water) resulted in complete suppression of bio-aerosol created by the air turbine and ultrasonic scaler.⁵⁰ This novel approach to managing bio-aerosol is the result of collaboration between engineering and dentistry at the University of Illinois. This study further emphasises that dental education post-pandemic must focus on research through wider collaborations to bring about translatable solutions for dental care and training.

5 | CONCLUSIONS

The SARS-CoV-2 pandemic has had significant impact on dental clinical education, which faces unique challenges compared to smaller dental facilities, both public and private. Dental educators have sought to identify these challenges and find solutions appropriate to the stage of the pandemic specific to their geographical location. Post-pandemic, dental academics must consider sharing their experiences via publication. This knowledge will enable dental academia to improve the overall education experience and future proof teaching in clinical and simulation settings into the future.

CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

DATA AVAILABILITY STATEMENT

Some of the data that support the findings of this study are available derived from public domain resources in the table outlined below. John Hopkins Corona Virus Resource Center,¹ <https://coronavirus.jhu.edu/>. Office of National Statistics (UK Government), Which occupations have the highest potential exposure to the coronavirus (COVID-19)? 2020 11 May; Available from: <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/whichoccupationshavethehighestpotentialalexposuretothecoronaviruscovid19/05-11>¹³ <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/whichoccupationshavethehighestpotentialalexposuretothecoronaviruscovid19/2020-05-11>. Centers for Disease Control and Prevention,²⁹ <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-at-increased-risk.html>. Australian Dental Association,³³ <https://www.ada.org.au/Transmission-Based-Precautions>. Australian Dental Association,³⁴ [https://www.ada.org.au/Campaign/COVID-19/Managing-COVID-19/Practice-Resources/Managing-COVID-19-Guide/ADA-Managing-COVID-19-Guide-v-2-\(1\).aspx](https://www.ada.org.au/Campaign/COVID-19/Managing-COVID-19/Practice-Resources/Managing-COVID-19-Guide/ADA-Managing-COVID-19-Guide-v-2-(1).aspx). APHRA and National Boards,³⁵ <https://www.ahpra.gov.au/News/COVID-19/National-principles-for-clinical-education-during-COVID-19.aspx>. NSW Health,³⁶ http://www.cec.health.nsw.gov.au/_data/assets/pdf_file/0010/575362/COVID-19-Infection-Prevention-and-Control-Advice-for-Health-Workers-V3.1.pdf. <https://www.health.nsw.gov.au/Infectious/covid-19/communities-of-practice/Pages/guide-public-dental-services.aspx>. NSW Health,⁴⁰ http://www.cec.health.nsw.gov.au/_data/assets/pdf_file/0010/575362/COVID-19-Infection-Prevention-and-Control-Advice-for-Health-Workers-V3.1.pdf

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